# JOURNAL

## OF THE INSTITUTION OF ELECTRICAL ENGINEERS

**VOLUME 7 1961**

*Published monthly price 7s. Annual subscription £2*

**THE INSTITUTION OF ELECTRICAL ENGINEERS**

**SAVOY PLACE LONDON W.C.2**

© 1961: The Institution of Electrical Engineers

## PAGINATION OF EACH ISSUE OF THE JOURNAL

| *pages* | *month (1961)* | *pages* | *month (1961)* |
|---|---|---|---|
| 1–78 | January | 403–486 | July |
| 79–138 | February | 487–536 | August |
| 139–202 | March | 537–586 | September |
| 203–268 | April | 587–646 | October |
| 269–334 | May | 647–710 | November |
| 335–402 | June | 711–780 | December |

*The Institution is not as a body responsible for the opinions expressed in the Journal unless it is stated that an article or a letter officially represents the Council's views*

PRINTED BY UNWIN BROTHERS LIMITED, WOKING AND LONDON

# JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME [illegible] NO. 19 JANUARY 1951

VOLUME 7 NUMBER SEVENTY-THREE JANUARY 1961

# JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 *Telephone* COVENT GARDEN 1871 *Telegrams* VOLTAMPERE PHONE LONDON

PUBLISHED MONTHLY PRICE SEVEN SHILLINGS ANNUAL SUBSCRIPTION TWO POUNDS

## Contents

FRONTISPIECE **Sir Hamish MacLaren**

1 **Annus mirabilis**

2 **The Presidential Address**

5 **Opening Meeting, 1960–61 Session**

7 **Malvern 45ft radio telescope**
*by* J. S. HEY, D.SC., *and* V. A. HUGHES, M.SC., ASSOCIATE MEMBER

12 **Addresses of the Section Chairmen**

16 **Talking about science**
*by* ARCHIE CLOW, M.A., D.SC., F.R.S.E.

18 **Confidence in electronic switching for telephones**

20 **Letters to the Editor**

24 **The Council of The Institution: meeting on 1st December 1960**

25 **A review of the *Proceedings*, Parts A and B**
(*details are given in the adjoining column*)

38 **Contents of the current *Proceedings***

38 **Paper and monographs published individually this month**
(*details are given in the adjoining column*)

39 **Obituary**

41 **Some recent books**

48 **Library accessions**

49 **Forthcoming events at Savoy Place**

49 **District Meeting**

50 **Elections and transfers**

51 **British Nuclear Energy Conference**

52 **Announcements to members**

55 **Bulletin of the Sections**

58 **London report**

62 **News from the Centres**

66 **Officers of The Institution**

70 **Representatives of The Institution on other bodies**

xl **Index of advertisers**

**25 A review of the *Proceedings*, Parts A and B**

| | |
|---|---|
| Brushless variable-speed induction motors | Prof. F. C. Williams, E. R. Laithwaite, J. F. Eastham, L. S. Piggott and W. Farrer |
| Radiocommunication in the power industry | E. H. Cox and R. E. Martin |
| Phase control of rotors at high spinning speeds | P. A. Egelstaff, H. J. Hay, G. Holt, J. F. Raffle and J. R. Pickles |
| Improved I.L.S. localizer | A. N. Beresford and J. D. Asteraki |
| Training of oversea graduate engineers | W. Abbott |
| High-resolution radio telescope | W. N. Christiansen, N. R. Labrum, K. R. McAlister and D. S. Mathewson |
| Railway-traction rectifier equipments | K. Gunary |
| Signal-generator calibration | D. Woods |
| Analogue computer for coal-flow simulation | E. G. Anderson |
| Electrical analogue for heat waves | R. T. Ackroyd, J. Houston, J. W. Lynn and E. Mann |
| Tuning of e.h.t. transformers | E. M. Cherry |
| Transverse-film bolometer | J. A. Lane and D. M. Evans |
| R.F. interference in f.m. system | R. Hamer |
| Coupled transmission lines as directional couplers | Ryutaro Koike |

**38 Paper and monographs published individually this month**

PAPER

| | |
|---|---|
| Neon glow-discharge tubes | F. A. Benson and G. P. Burdett |

MONOGRAPHS

| | |
|---|---|
| Travelling-wave analysis of generalized networks | J. Zawels |
| Optimum sampled-data control | R. Jackson |
| The stability of permanent magnets | C. E. Webb |

## SHOOTING THE SUN

THE cover illustration this month shows a portion of a crossed-grating interferometer—a novel decimetre-wavelength radio telescope which has been built near Sydney, Australia, by the Radiophysics Division of the Commonwealth Scientific and Industrial Research Organization. The instrument uses two long arrays, each made up of 32 parabolic aerials, arranged to form a cross. It has a very narrow pencil-beam response (the beamwidth is only 0·05°). This high resolution has made it possible, for the first time, to produce detailed 'radio pictures' of the sun. The interferometer has been in regular use for this purpose since 1957.

An article describing this equipment will be found on p. 32. The Malvern 45ft radio telescope is discussed in another article on p. 7

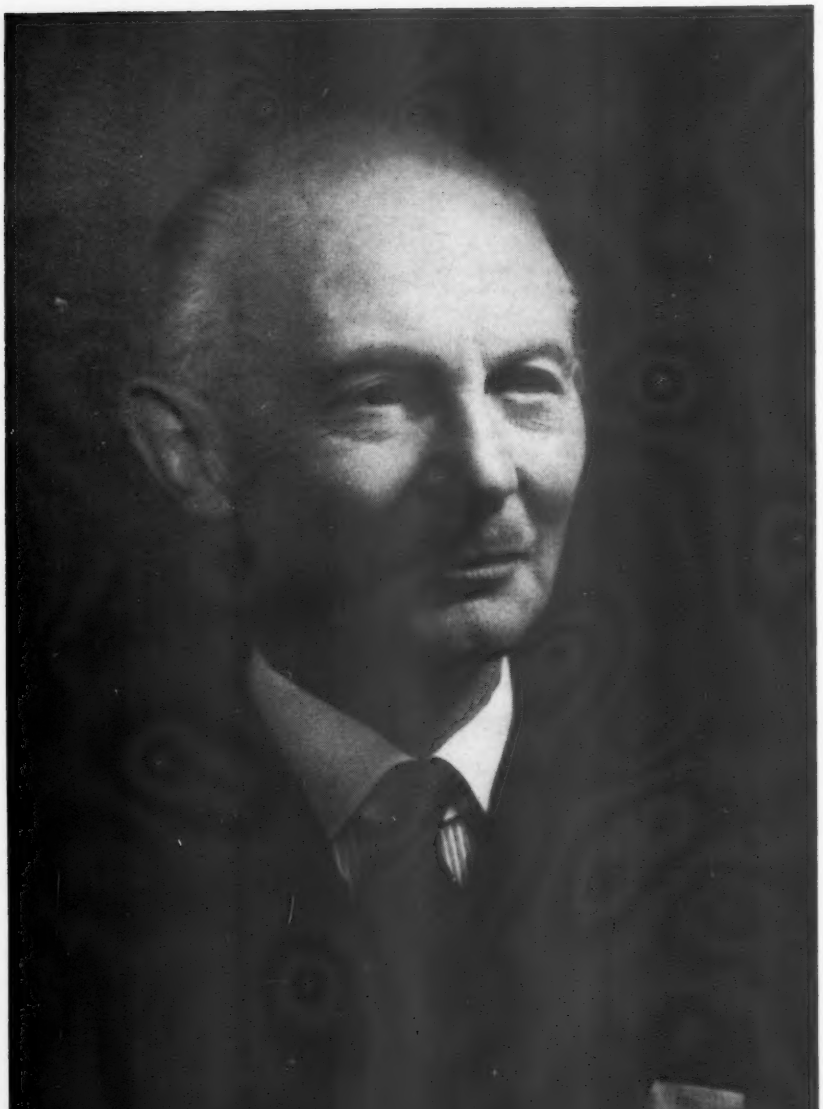
*The President and Council send good wishes for the New Year to all members of The Institution, and with these greetings the Secretary and members of his staff would like to be associated*

*Secretary* W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

©1961: The Institution of Electrical Engineers

ADVERTISEMENT INQUIRIES SHOULD BE ADDRESSED TO THE ADVERTISEMENT DEPARTMENT, THE INSTITUTION OF ELECTRICAL ENGINEERS, SAVOY PLACE, LONDON W.C.2

The Institution is not as a body responsible for the opinions expressed in the *Journal* unless it is stated that an article or a letter officially represents the Council's views



**SIR HAMISH MACLAREN** PRESIDENT 1960–1961

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 VOLUME 7 NUMBER 73 JANUARY 1961

# ANNUS MIRABILIS

We Scots are alleged to make much of the New Year, allocating Christmas to a secondary place in what is generally referred to as the festive season. Thus New Year's Day is traditionally a public holiday in Scotland, while Christmas Day with its appendage Boxing Day are not so honoured. That was the position 40 years ago. It may be that things are not now as they used to be.

Be that as it may, I, your first Scots President since 1948, derive a peculiar satisfaction from having this opportunity to wish you all a 'Guid New Year'.

For me 1961 will be unique—my *annus mirabilis*. For the first nine months, I continue the never-to-be-forgotten and never-to-be-repeated experience of being your President. As I write this message, I have been in the Chair for two months. My first impressions are that it is a tremendous experience, transcending all my previously formed impressions of what it would mean. As a Vice-President, one tended each year to centre one's interest rather closely on the Council Committee whose chair one happened to have the privilege of occupying. From the dais of our new Council Room, and sitting *ex officio* on all Committees of Council, the President sees the whole more closely knit together than ever before, and the general pattern of our *raison d'être* and objectives becomes much sharper.

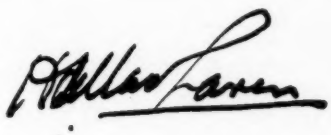
By the time you read this message, I hope to have visited five of our local Centres or Sub-Centres and attended the Annual Dinner-Dance of the Irish Branch in Dublin. So far, five of these visits are behind me, and I should like to record my appreciation of the welcome which everywhere has been forthcoming. It makes light of what would otherwise be rather an arduous duty. I wish again to thank all concerned for their welcome. I greatly look forward to the other six visits on my roster, and my wife does so also so far as she is concerned. To the other Centres and Sub-Centres not on my list, I should say how much I would like to include you; but you will understand that it just is not possible, and if it were, the Vice-Presidents would be up in arms at being denied such stimulating and educating experiences!

We look forward early in 1961 to the completion of the reconstruction of our headquarters at Savoy Place. We owe our staff a tremendous debt of gratitude for the cheerful way they have carried on our business efficiently in very uncomfortable surroundings for over two years. I hope as many of you as can will accept our invitation to attend the 1961 Summer Meeting in London. This will give you an opportunity to see the results of our modernization and enjoy a varied programme, the details of which are being worked out by a committee.

Although Janus, the god from whose name January is derived, is depicted as looking both ways, it is, I think, mostly to the future that we look, by well established custom, on the 1st January. This looking forward is often accompanied by making good resolutions for the coming year. May I suggest one such. It is that we Corporate members should examine ourselves and see if we are satisfied that we are doing all we can to help our Graduates and Students.

The future depends on these young men, and, in displaying an interest in them, we older members are doing no more than we ought to if we are to justify our claim to be a forward-looking profession, or a profession at all for that matter. The interest already taken in their activities by some of our Corporate members is, I know, greatly appreciated; but more could be done for them by supporting Graduate and Student meetings, and by those in positions of authority making it easy for Graduate and Student members to attend functions such as meetings, committee meetings, and visits to works. Our Institution depends on what our members put into it, and here we have a case which will prove very rewarding.

I finish this message by wishing you all 'A Very Happy and Prosperous New Year'. For me, I know, it will be the former!



THE PRESIDENTIAL ADDRESS

# ELECTRICAL ENGINEERING IN THE ROYAL NAVY

621.3 :623.96

*This is a much condensed version of the Address given by Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C.*, LL.D., B.Sc., at his inauguration as President of The Institution on the 6th October 1960 (see p. 5). The complete text will be published in Part A (February 1961) and Part B (January 1961) of the Proceedings.*

At the start, Sir Hamish referred to his 34 years' service with the Admiralty, and to his being within a month of retirement. However, the prospect of his forthcoming presidential year would help to soften the blow of saying goodbye to a Service which had provided a professional life of absorbing interest.

He recalled that the cost of warship electrical installations now accounts for about 30% of the cost of the ship; and, although the Director of Electrical Engineering is not directly responsible for some of the very specialized applications, he is responsible for the installation of all equipment and for its compatibility in operation in the ship as a whole. 'Security' limited the subject-matter for the Address, but in any case he felt it would be more appropriate to select a topic of interest to the largest number, and so he reviewed the application of electricity in the Royal Navy from the earliest days to the present time.

## First electricity afloat

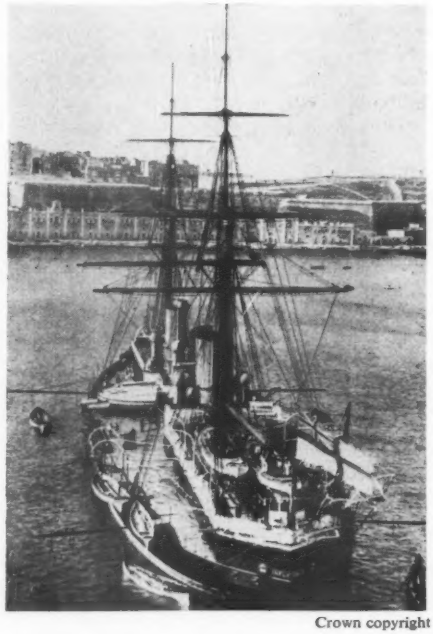
The first application of electricity afloat was in the 1870s, when electric firing of guns was introduced. Pile-type batteries were used, consisting of 160 sheets of alternate copper and zinc separated by 'fearnought'—a kind of flannel used for stokers' trousers, dipped in a mixture of vinegar, salt and water.

The first dynamo was installed in 1875 to provide power for a searchlight for use against torpedo craft, while H.M.S. *Inflexible* (Fig. 1) in 1881 was the first ship to have electric lighting and searchlight installations. In this ship, incandescent lamps were connected in series to an 800volt d.c. generator. This was not very satisfactory, and within a year the first fatal accident was recorded; 80volts was then adopted as standard, and by about 1885 some 100 vessels had searchlights and ten had electric lighting.

In those days, cables were rubber insulated, with a serving of cotton tape coated with preservative, and they were run in teak casings and embedded in putty. This was later replaced by a lead sheathing with layers of jute yarn instead of rubber. These all gave trouble, but a change to rubber insulation with a lead sheath in 1888 was much more successful, and this basic type of cable, with of course many improvements, continued to be used up to the end of the Second World War.

A first-class ship in the 1880s had three dynamos, each giving 200amp at 80volts, but by the turn of the century the power demand had grown so much that 600amp dynamos were necessary. In 1899 an 'Electrician' was appointed to Portsmouth Dockyard, and he recommended increasing the voltage to 100. Soon after this, the Board of Admiralty set up a committee to have this new thing, electricity, thoroughly looked into, and the outcome was the appointment in 1903 of Charles Wordingham (President of The Institution from 1917 to 1918) as the first electrical engineer at Admiralty Headquarters.

By 1905, proposals were made to raise the voltage to 220, tests having shown that '220volt shocks were unpleasant but not dangerous'. In 1908, H.M.S. *Defence* (Fig. 2) was completed, the first ship to have a 220volt system. She also made history in that a watertight ring-main system was installed, a fundamental departure from the simple central switchboard hitherto used. The ring-main system, with many improvements resulting from experience in peace and war, is still at sea in many of our larger ships. In the early ring main, electrical equipment connected directly to it had to be in watertight enclosures, so that flooding in any part of the ship involving ring-main equipment would not lead to short-circuits and loss of power.



Crown copyright

1 *The first warship to be fitted with an electric-lighting and searchlight installation (1881)*

## The First World War

Experience in the 1914–18 War showed that the watertight equipment rarely remained so in service, and it was not easy to isolate damaged and flooded sections under stress of action. This led to the development of an unusual piece of apparatus called the 'main guard', which consisted of a miniature diving bell carrying an interrupter. The latter carried the load current from the generator; and, in the event of flooding of the compartment, a flood-switch circuit was completed, firing an explosive charge in the interrupter and opening the circuit isolating the watertight from the flooded non-watertight equipment.

A later development to take the place of the main guard was the fuse-release switch, in which a toggle-operated switch was held in the closed position against a spring by a stainless-steel fuse which in turn was connected to the flood switch. Ring-main breakers were also introduced to automatically isolate damaged sections of the ring.

The 1930s saw a considerable expansion of warship construction, including the introduction of a new class of ship altogether, the aircraft carrier. The *Ark Royal* was the first ship to be designed and built as an aircraft carrier, and she had six 400 kW generators. The growing size of the electrical installations raised doubts as to the effectiveness of the fault-protection system as used on the ring main and also as to the ability of the circuit-breakers to deal with the fault currents which might well now be expected.

In late 1938, H.M.S. *London* was made available for extensive trials, consisting of imposing a comprehensive series of low-impedance faults on the system with various combinations of generators running in parallel. The maximum short-circuit current measured during the trials was 33000 amp with the four generators in parallel, and this was about the maximum which the type of ring-main switchgear then in use could interrupt safely.

Discrimination between circuit-breakers was found to be unsatisfactory, and new overcurrent relays had to be designed which could be fitted in existing ships. Circuit-breakers had to be fitted with back-up protection in the form of high-breaking-capacity fuses, and switchgear makers were given the task of developing breakers of higher breaking capacity for future installations.

This period also saw a steady growth in the use of power and in the functions of communication, data transmission, computation, and so on. At the Admiralty Research Laboratories, work of far-reaching importance was undertaken, for example on the use of the magslip for data transmission and on the plotting table automatically recording a ship's position on a chart.

## The Second World War

Sir Hamish then turned to the 1939–45 War, referring first to the problem of the magnetic mine. The first sweeps were energized coils wound on wooden rafts towed at a safe distance behind the wooden towing vessel. These were followed by the magnet ship—a remarkable vessel which had a 100 ft magnet weighing some 500 tons fitted to its forward end. The magnet was energized from a d.c. generator, later converted to a source of low-frequency a.c. supply, to sweep mines of north and south polarity.

Crown copyright

**2** *The first warship to be fitted with a 220 volt watertight ring-main system (1908)*

Use of these ships had to be discontinued when mines came to be armed with a device requiring an unknown number of actuations before exploding. Real success came when the towed-buoyant-cable sweep was developed. This method consists in producing a large magnetic field in the sea by pulsing currents of several thousand amperes through a loop of buoyant cable towed by the minesweeper.

In addition to sweeping magnetic mines, there was also the problem of making ships safe by fitting degaussing coils. Early installations consisted of coils sewn up in canvas and clipped outside the hulls. The next development was a single turn of rubber-insulated heavy copper strip fitted to the external plating. After considerable research in 1940, it was found possible to obtain effective screening with the coils inside the ship's plating.

One of the first ships to suffer from a magnetic-mine explosion was H.M.S. *Belfast*. The hull was severely damaged, and the extensive damage to the electrical equipment was sufficient to immobilize the ship. It was thus clear that the mechanical-shock effects resulting from a non-contact underwater explosion were much more severe than had been anticipated. Resistance to mechanical shock was no new problem, and a shock-simulating machine had been in use for many years.

Fortunately, *Belfast* provided valuable data because it was possible to pick out certain identical items of equipment dispersed through the ship, some of which had suffered damage and others not. It was thus possible to decide how much to increase the intensity of simulated shock to produce corresponding damage, and to design a new shock-testing machine to the new parameters. A new machine was designed and made at the Admiralty Engineering Laboratory, and later similar machines were

installed in the works of the principal manufacturers. Drawings were also passed to the United States Navy so that they might benefit from our experience.

It was a great blow when H.M.S. *Ark Royal* was lost in November 1941. Although hit by one torpedo only, the result was disastrous, as it resulted in the immediate flooding of a boiler room and the main switchboard control room. It became impossible to control the system, and hand operation was impossible because of the state of the ship. It was evident that development of a new control system was of paramount importance. The outcome was a relay system in which all the control cables were normally dead. The new system made it practicable to introduce secondary control positions in the ship which could be brought into operation if the main control position became unserviceable.

The loss of *Ark Royal* emphasized another important factor, namely the necessity for having generators for maintaining essential supplies after loss of steam; and immediate steps were put in hand to fit Diesel-generators in those ships where none existed. At the same time, automatic changeover switches were introduced to provide alternative power quickly to close-range anti-aircraft gun mountings and other essential services.

Electrical engineering played a much larger part in the war at sea than earlier experience had led one to expect. One example is the development of remote-power-control systems for automatic control of armament in the early months of the war. War experience led to the development of the damage-control organization for all departments of the ship, which included a special communication system and secondary lighting by automatic emergency lanterns.

The pattern of the war at sea, the effect of non-contact underwater explosions and bomb damage, raised doubts as to the effectiveness of the ring-main system, which were much in mind when the pros and cons of the changeover to alternating current were investigated after the war.

## Changing to alternating current

The possibility of changing to alternating current had been investigated after the First World War and again in the early 1930s, but the balance of opinion was then in favour of retaining direct current. However, the prospect of fitting generators of 1000 kW capacity or more for even smaller ships in the post-war era made a reappraisal of the position essential. It was clearly necessary to raise the voltage and to decide whether direct or alternating current should be used. Investigations showed that, even for a small vessel with some 1000 kW of generating capacity, a 440 volt 3-phase system operating at 60 c/s could result in a saving of weight and space, with an increase in saving as the size of the installation increased.

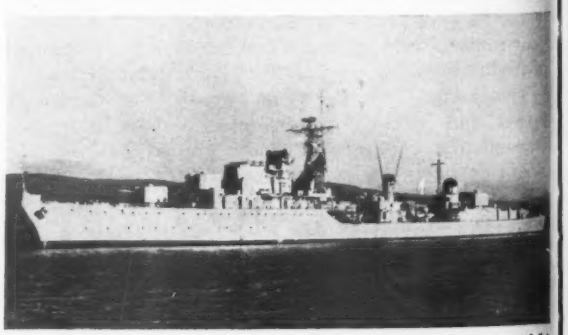
The selection of frequency was not easy, but it was evident that a motor speed of 1800 r.p.m. met a large number of requirements and that the lower speeds associated with a 50 c/s supply would introduce a quite unacceptable weight penalty. So, with the full support of industry when the facts were put before it, 60 c/s was selected.

The first ship to complete with alternating current was H.M.S. *Diamond* (Fig. 3), and this was followed by several classes of frigate. The Tiger-class cruisers were the first large ships to have an a.c. system. These were laid down during the 1939–45 War but were not completed by the end of the war. Changing to alternating current on completion with modern weapons and radar made it possible to meet the very much greater electrical demand by substituting 1000 kW a.c. generators in place of the original 500 kW d.c. machines.

The change brought many new problems, ranging from automatic voltage regulators for the a.c. generators, to give very close control of system voltage, to air-break switchgear, control gear, distribution equipment, emergency cable system, etc. to meet the naval specifications, including resistance to mechanical shock. The earliest opportunity was taken to study system and switchgear behaviour in fault conditions in an a.c. ship, and trials carried out in H.M.S. *Diamond* showed that changes were necessary to improve discrimination in fault protection.

Sir Hamish referred to developments in other aspects of naval electrical engineering, varying from conversion equipment and demagnetization to one of the outstanding achievements of his department—the development of electrical analogue-computing systems for gunnery. Communication plays a vital part in the running of a warship, ranging in the modern vessel from straightforward 500-line automatic exchanges for administrative purposes to a series of operational communication systems. The most complex of all permits aural communication with an ambient noise level of 130 dB—a condition which has to be met on the flight deck of a carrier when the aircraft jet engines are running.

He concluded this part of his survey by referring to the introduction of silicone-rubber insulation for cables, which permits higher ratings and, what is most important, remains effective after damage by fire, as the residual ash is non-conducting. Other changes have been the adoption of cable hangers instead of the old carrier plating,



Crown copyright

3 *The first warship to have a 440 volt 3-phase 60 c/s system (1950)*

and the development of a multiple-type gland box, with considerable saving in bulkhead space.

On submarines, Sir Hamish mentioned the T-class conversion, where the vessels were cut in two and lengthened to permit the installation of a fourth battery section and an additional propulsion motor on each shaft to give higher underwater speeds at 440 volts.

The Porpoise class, which followed, was a radical departure from previous design practice, as, for maximum speed, the batteries are connected to give 880 volts, while for ordinary working the voltage is 440. Motor-driven cam-contactor switchgear is used, and special attention had to be paid to fault protection by means of high-speed high-breaking-capacity switchgear. To test the equipment, one of the largest d.c. short-circuit-testing installations in Europe was built at the Admiralty Engineering Laboratory.

## The future

Looking to the future, Sir Hamish thought that the pattern of increasing specialization in design must continue to an even greater degree. The serving naval electrical engineer and his civilian counterpart will need to be of the same high standard or even higher. In the material field, thanks to the close co-operation existing between the Admiralty and the electrical industry, knowledge of new discoveries and developments becomes available at a very early stage, so that possible naval applications can be kept in mind.

The biggest drive will be for increased reliability and reduction in size and weight. Generation of power may be at higher frequencies than 60c/s, and higher voltages than 440 may well be necessary. The fuel cell and thermo-electric generators may become practicable, though much development remains to be done. Nuclear propulsion of submarines is already proved, but if it can be justified for surface warships it will present problems still to be tackled.

Sir Hamish concluded his Address by saying that these and similar problems would keep his successors in naval electrical engineering fully occupied, and would exercise their ingenuity and that of their colleagues in industry and elsewhere, whose enthusiastic co-operation would be just as essential in the future as it had been fruitful in the past.

---

**OPENING MEETING, 1960-61 SESSION**

# A NAVAL OCCASION

At a highly successful first night in the completed new Lecture Theatre at Savoy Place on the 6th October 1960, Sir Hamish MacLaren delivered an Address on electrical engineering in the Royal Navy (see p. 2) and was inaugurated President of The Institution for 1960–61.

*Sir Hamish MacLaren delivers his Inaugural Address*

### Handing over

The Theatre, transformed in two steps over two years but seeming to retain in its newness some echoes of the past, was formally handed over by Sir Gordon Radley, Chairman of the Building Sub-Committee, 'with a great feeling of thankfulness'.

Sir Willis Jackson, the retiring President, warmly thanked Sir Gordon and his committee. He announced the gifts to the Benevolent Fund and the Homes Fund, welcomed new Corporate members, presented premium certificates, and then called on Sir Hamish to give his Inaugural Address.

The new President was, until his retirement at the end of October 1960, Director of Electrical Engineering at the Admiralty. Elected a Member of The Institution in 1945, he has served on the Council from 1950 to 1953 and from 1954 to date. He was a Vice-President from 1955 to 1960. He has served on all the principal committees of the Council and, from 1952 to 1956, on the Joint Committee on Practical Training in the Electrical Engineering Industry.

### Good old days

Sir Hamish, who in feature and delivery somewhat resembles Lord Montgomery, presented a condensed version of his full Address, and by means of salty phrases and vivid illustration managed to bring a whiff of the broad oceans to Savoy Place. Before 1852, a message could be sent by

semaphore from Whitehall to Plymouth and an answer received back in 15 minutes, which made the President-Elect long for the good old days.

*The new President presents the Certificate of Presidency to Sir Willis Jackson*

---

The flannel for stokers' trousers, which was used for electrode separation in the Navy's pile-type batteries of the 1870s, was called 'fearnought', which was fair enough in a Service which in 1905 announced that '220volt electric shocks are unpleasant but not dangerous'.

In the Second World War, 'two types of buoyant cable were designed literally overnight by two firms whose names are (or used to be!) household words in the cable industry, and in each case the inventor was a Past-President of this Institution'.

### Shock

H.M.S. *Belfast*, the first ship to suffer from a magnetic-mine explosion, in October 1939, provided valuable data on the very serious effect of shock on electrical equipment. A new shock-testing machine was designed, and drawings were given to the United States Navy. Here Sir Hamish presented a short film 'Shock' with himself as commentator. Whatever we expected from the title, we were shown some eerie effects of high-speed photography in a warship subjected to the full force of an underwater explosion. Equipment, including radar, moved in strange undulating contortions, bits and pieces floated through the air, and flexible lighting fittings indulged in a weird snake-dance.

Another short film provided a rousing finish to the Address —not that anyone needed rousing. 'Ships of the Royal Navy at sea', commentator Sir Hamish MacLaren, was what is known as a 'spectacular'. Scenes of naval manoeuvres, fleet aircraft and gunnery, and the interior of a submarine culminated in a proud finale to the strains of 'Heart of oak'.

### Thanks

**Mr. Brian Donkin** said that the Admiralty had been quicker to see the advantages of electricity than they had been to see those of steam. The Engineering Branch of the Royal Navy, though, had been tardily recognized. Sir Hamish's work at the Admiralty, and the work of others like him, had probably had a great influence in enhancing the status of the professional engineer in the eyes of their Lordships.

He moved 'That the best thanks of The Institution be accorded to Sir Hamish MacLaren for his Inaugural Address to us this evening', and this was carried by acclamation.

Sir Willis Jackson then vacated the Chair and, amid applause, inducted into it the new President, Sir Hamish MacLaren.

**Mr. S. E. Goodall** proposed 'That the best thanks of The Institution be accorded to Sir Willis Jackson for the very able manner in which he has filled the office of President during the past year'.

During their year of office, Presidents usually suffered from expansion by hospitality, laryngitis by speaking, and exhaustion by travelling. Sir Willis had also suffered from percussion and deafening by builders.

However, he had made notable contributions to strengthening the links between the three major engineering institutions. The Institution had had an exceptional year, due in no small measure to the inspiring leadership of Sir Willis. They were also deeply indebted to Lady Jackson for all the support and help she had given her husband.

The vote of thanks was carried by acclamation.

### Tributes

Sir Willis Jackson, having received the Certificate of Presidency, spoke of his year as a marvellous experience of help, encouragement, hospitality and kindness. He paid a heartfelt tribute to the work and devotion to duty of the Secretary and his staff, and to the outstanding service of Mr. Ernest Leete, retiring on the completion of his fourth three-year term as Honorary Treasurer.

Mr. Leete had joined The Institution as an Associate in 1917, had become a Companion in 1929, and had been elected an Honorary Member in 1954 for his great services, in particular as Honorary Treasurer and as a member of Council for approximately 25 years. He had also done an immense amount for the Benevolent Fund.

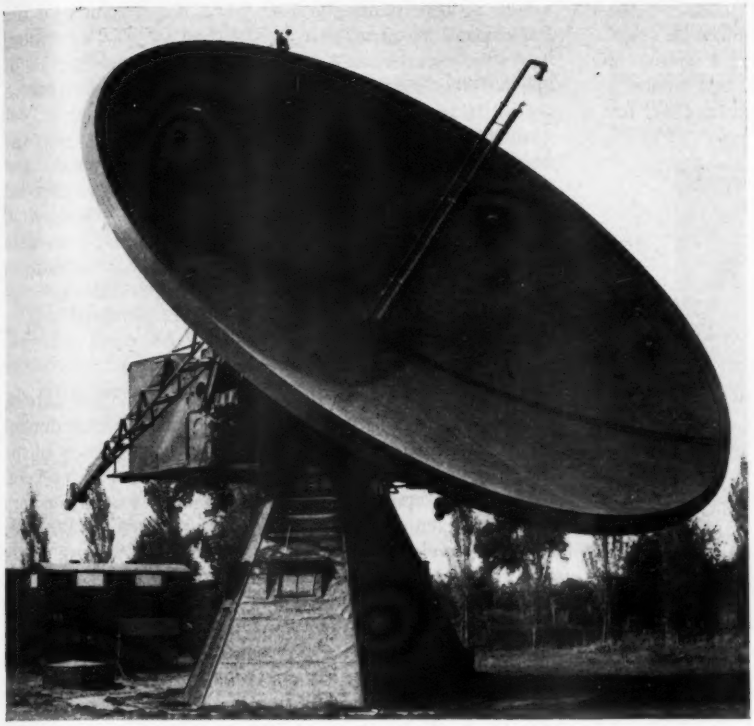
The President then closed the meeting.

---

## A change of habit

It will not have escaped notice that this month's cover appears in red. In thus changing the colour, we are reverting to an earlier *Journal* custom which enables those who keep files to distinguish between the issues of different years and, as well, adds variety to the appearance.

Another innovation is the advertisement on the outside back cover. This has been done to increase revenue, in accord with the wish of most members of The Institution and with the statement of the Special Advisory Committee and accepted by the Council that '. . . we are satisfied with the *Journal* and are anxious to see it develop along its present lines, but we consider that every effort should be made to reduce the proportion of subscription income which it absorbs'.



1

# Malvern 45ft radio telescope

621.396.677.833

*The article describes the construction of the 45ft radio telescope completed at the Royal Radar Establishment, Malvern, in 1957, and applications at centimetric wavelengths to radio astronomy and Earth-satellite observations. The authors are at the Royal Radar Establishment, Malvern.*

**J. S. HEY**, D.SC., and **V. A. HUGHES**, M.SC.,
ASSOCIATE MEMBER

ALTHOUGH only 45ft in diameter, the instrument at the Royal Radar Establishment is the largest radio telescope for centimetre wavelengths which has been in operation in Britain. The equipment, shown in Fig. 1, utilized the turning mechanism and cabin of a Giant Wurzberg radar, which was mounted on a tower and fitted with a parabolic reflector of 45ft aperture. Despite this improvisation, which made it possible to complete the construction in a year and at low cost, the final equipment provided an excellent steerable radio telescope for use at wavelengths down to a few centimetres.

The first Russian Earth satellite was launched soon after completion of the radio telescope in 1957, and a high-power radar was consequently installed to make centimetric-radar observations. This article surveys briefly the performance of the radio telescope at centimetric wavelengths, considers its capabilities for radio astronomy and Earth-satellite observations, and describes some results which have been obtained.

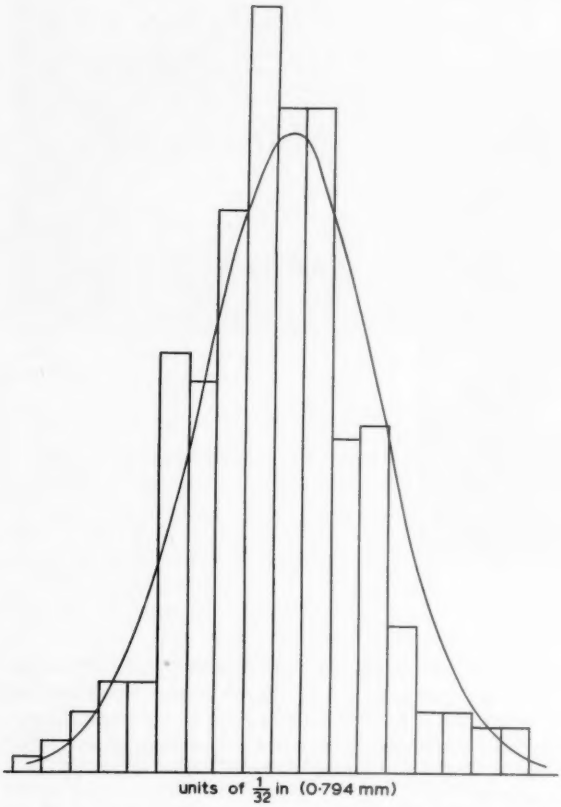
## The 45ft reflector

The reflector was made from preformed sheets of aluminium alloy riveted to a framework previously adjusted to the required parabolic contour. The same metal was used for both frame and surface to avoid differential expansion, with the advantage of lightness in weight.

If a parabolic reflector is perfect, the path length of all the reflected rays from the focus to the aperture is the same. The waves at the aperture are then exactly in phase, and the aerial has maximum gain. If, however, the reflector surface has random deviations from the true paraboloid, there will be corresponding random deviations of phase across the aperture. As the waves no longer add exactly in phase along the axis, the gain of the aerial is reduced, while the sidelobes are increased.

The effect on the sidelobes depends not only on the magnitude of surface deviations but also on their lateral scale. If this scale is large compared with the wavelength $\lambda$, the sidelobes close to the main beam have increased amplitude. If the scale is small (a rough surface), the near sidelobes are reduced in amplitude but sidelobes in other directions have increased amplitude.

Then there is the effect of surface deviations on the main beam. It is clear that the deviations must be small compared with $\lambda/4$, since this corresponds to a change of total path length after reflection of $\lambda/2$ and hence a complete reversal of phase. It can be shown that, for small random deviations of the surface, the gain is less than that of an ideal aerial by a factor $\exp(16\pi^2\sigma^2/\lambda^2)$, where $\sigma$ is the r.m.s. deviation from the ideal surface. If $\sigma$ is $\lambda/16$, the gain is about 55% of the optimum, a very appreciable reduction. In practice, the surface accuracy is normally specified in terms of the largest deviations. If for 90% of the surface the deviations are less than $\lambda/16$, the r.m.s. deviation will be of the order of $\lambda/50$, and the gain is about 95% of optimum.




**2** *Histogram of surface deviations in the 45ft-diameter radio telescope*

The smooth curve is the random-error curve for the same r.m.s. deviation of 0·094in. (2·4mm)

To estimate the efficiency of the 45ft reflector, measurements of surface deviations were taken at 2ft intervals along 32 radial directions midway between the radial supports. The measurements are shown in the histogram of Fig. 2; the r.m.s. deviation is 0·094in. (= 2·4mm), which is approximately $\lambda/40$ when $\lambda = 10$cm, and the corresponding aerial gain is just over 90% of optimum.

As the measurements were taken at the mid-points of the reflector panels, where the errors would be expected to be largest, the efficiency should be better than this estimate. On the other hand, the deviations may be increased in certain conditions; such as wind, and unequal heating when part of the surface only is exposed to sunlight. Operation has taken place only with wind speeds of less than 30m.p.h., and in practice the radio performance has not indicated any significant variations in gain of the reflector due to ambient conditions.

## Operation of the radio telescope

A radio telescope with a parabolic reflector can be used at any wavelength smaller than the reflector dimensions, down to the limit imposed by the precision of the reflector surface, as discussed above. There are several reasons why special emphasis has been laid on using very short wavelengths with the 45ft radio telescope. Whereas longer wavelengths are appropriate for studying many radio-astronomical phenomena, there are aspects in which the extension of observations to short wavelengths is very important, and comparatively little work at centimetre wavelengths has been done in Britain.

A special quality of short-wavelength operation is apparent in observing thermal radiation. According to the Rayleigh–Jeans law, the power emitted per unit area per unit solid angle from a perfect radiator at temperature $T$ is $2kT/\lambda^2$, where $k$ is Boltzmann's constant. Thus, the shorter the wavelength, the greater is the power flux. This means that thermal radiation at radio wavelengths from objects is more easily detected at shorter wavelengths; consequently, observations of thermal emission from the Moon and planets have all been at centimetre or millimetre wavelengths.

If the source of emission is an ionized gas, such as the ionized hydrogen surrounding very hot stars, the radiation emitted depends not only on the temperature but also on the opacity of the gas to the radio waves. If the gas is semi-transparent, it is inefficient as a radiator, and, as its efficiency varies as $\lambda^2$, the received power flux is proportional only to $T$. Even so, thermal sources tend to dominate the radio-astronomical picture of radio sources at short wavelengths, because the radiation from the numerous non-thermal radio sources falls off more steeply with wavelength.

Another advantage to be gained at shorter wavelengths is that, for a given aperture, the beamwidth is narrower and the angular resolution is improved. With an aperture of diameter $D$, the wave for one half of the aperture is out of phase with the other half at an angle $\lambda/D$ off maximum. Thus the beamwidth is approximately $\lambda/D$, and the corresponding solid angle of the beam $\lambda^2/D^2$. Hence, the radio telescope is more directional as $\lambda$ is reduced, and in radar applications longer detection ranges can be achieved because more of the transmitted energy is concentrated on the target.

## Directional control

The reflector turns about horizontal and vertical axes, and its position is indicated by magslips. With the aid of servomechanisms, any desired direction can be set very quickly by manual control. However, the telescope is sometimes required to make continuous observation of a celestial object such as a radio star. Now the declination of a star remains constant, while the hour angle alters at a uniform rate with the rotation of the Earth. The radio telescope uses a device in which these celestial co-ordinates are automatically converted into azimuth and elevation with the aid of a mechanical model.

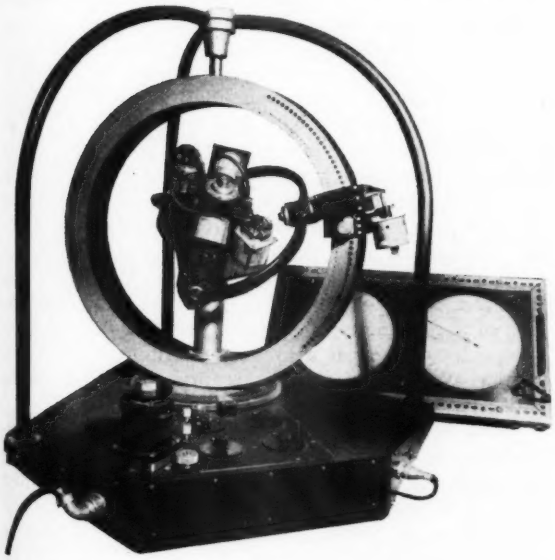
This mechanical analogue convertor, which enables a star to be followed continuously in azimuth and elevation, is shown in Fig. 3. The over-all pointing accuracy with the convertor is within a few minutes of arc.

## Reflections from Earth satellites

The power $p$ received from a radar target is given by the radar equation:

$$p = \frac{PA^2\sigma}{4\pi\lambda^2 R^4}$$

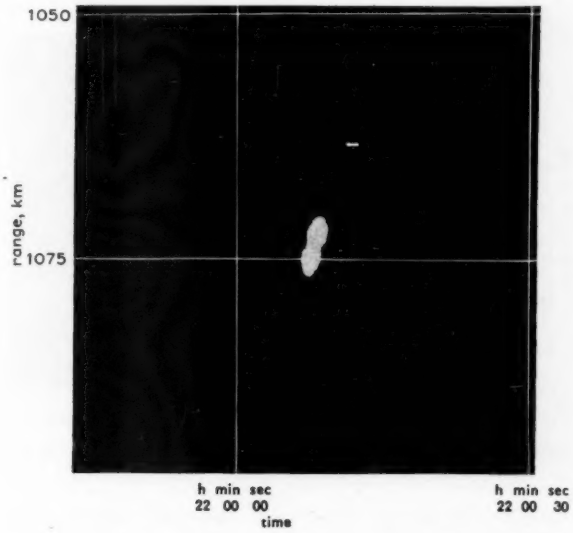
where $P$ is the transmitted peak power, $A$ the effective aperture of the radio telescope, $R$ the range of the radar target, and $\sigma$ the equivalent echoing area of the target.



3 *The co-ordinate convertor*

The maximum detection range depends on the ratio of the power received in the reflected pulse to the noise power, part of which is generated by the receiver and part collected externally. This noise power is proportional to the bandwidth of the receiver, so that bandwidth should be kept to the minimum necessary for the reception of the pulse.

The optimum receiver bandwidth is $1/\tau$, where $\tau$ is the radar pulse length. Allowance must be made for Doppler shifts in frequency when observing high-speed targets.

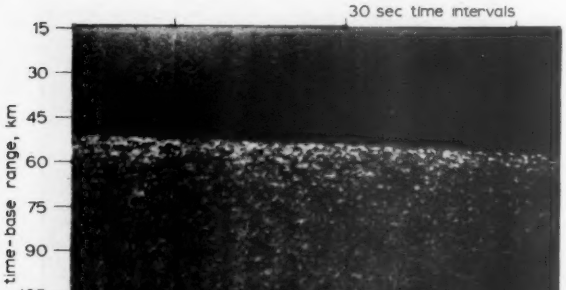



4 *Photograph of radar echo from the rocket of the first Russian satellite (1957α1) as it passed through the beam of the radio telescope on the 3rd November 1957*

The 10cm transmitter installed in the 45ft radio telescope has a peak power of 2MW and a pulse length of 5microsec. With a conventional receiver in the radio telescope, detection range can be estimated to be about 1000 miles for a target of equivalent echoing area 1m² (which is the echoing area of a sphere of 1m² cross-section). The strong radar signal received from the Earth satellite 1957α1, the carrier rocket of the first Sputnik, as it passed through the beam of the radio telescope is shown in Fig. 4. As the beamwidth is less than half a degree, the satellite had passed through in a few seconds.

The possibility of using Earth satellites as reflectors for long-distance radiocommunication is of current interest. For this purpose, inflatable aluminized satellites of diameter of the order of 100ft are being considered. Received power is proportional to echoing area, which for this size of sphere is about 650m². The bandwidth required for a speech channel is of the order of kilocycles per second, as compared with several hundred kilocycles per second required for a 5microsec-pulse radar, and reducing the bandwidth produces a corresponding increase in signal/noise ratio. Against this, transmitter powers for modulated c.w. will be less than are possible for short-pulse radar.

There are certain practical difficulties: for instance, communication is limited to line-of-sight visibility from the satellite to both the sending and the receiving station; the receiver must take into account Doppler shifts arising from the satellite motion; and there is the problem of keeping narrow aerial beams directed towards the




**5** *Photograph of radar echo from the Moon on intensity-modulated display (mean distance = 400000 km)*

satellite. However, these are technical rather than fundamental problems, and it certainly appears that the required signal strengths should be achievable, especially now that more-sensitive receivers, such as parametric amplifiers, are becoming available.

## Radar echoes from the Moon

Radar echoes from the Moon are of interest not only because they provide information about the nature of the surface as well as an accurate measure of the lunar distance, but also because they give detailed knowledge of the effectiveness of the Moon as a reflector for long-distance communication. If the surface were perfectly smooth, the reflected signal would be returned without distortion and appear to come from the nearest point of the surface.

If the surface were rough, with irregularities of height and size comparable with the wavelength, then all parts of the surface would contribute to the reflected signal, which would extend to the limb of the Moon. This would cause lengthening of a returned radar pulse, and in any reflected signal there would be a distortion of high frequencies of modulation. In actual fact, the surface behaves to radio waves as a nearly smooth reflector.

The Moon echo obtained with the 10cm radar in the 45ft radio telescope is shown in Fig. 5, where the bright leading edge is the reflection from the nearest point and the intensity of the echo falls steeply at greater distances. As the pulse length is 5microsec, corresponding to 0·75km, the characteristics of the echo can be distinguished to this accuracy of range. The drift of the echo in range is mainly due to the movement of the observing site with the rotation of the Earth.

All parts of the echo show rapid fluctuations of amplitude which can be explained by the contributions of different surface irregularities combining with altering phase relationships. The rate of fading can be related to the approach and recession of the surface with the libration of the Moon, the echo fluctuating more rapidly at increasing distance from the leading edge, as might be expected.

The fall of echo amplitude away from the leading edge indicates the angular-scattering law. To determine this accurately, the effective signal/noise ratio was improved by introducing a range gate to integrate the signals at different ranges. With a gate corresponding to approximately 5km of range, and with 2sec integration time, signal amplitude at only 3% of the noise level could be measured.

The ratio of scattered power to incident power was found to be given by:

$$\sigma = 0{\cdot}7 \exp(-10\theta)$$

where $\theta$ is the angle of incidence at the mean surface. This scattering law indicates that there is a random distribution of surface irregularities, of many wavelengths in magnitude but of gradual mean slope (about 1 in 20), which produce the main contribution to the radar echo. The echo amplitude indicates a surface reflectivity of less than 0·1. The total scattering cross-section of the Moon obtained by integration is $0{\cdot}014\pi a^2$, where $a$ is the lunar radius, as compared with $\pi a^2$ for a perfectly reflecting smooth sphere of the same size.

In a joint experiment with the University of Texas, as a further test of the Moon's reflecting properties, radar pulses at 10cm wavelength were transmitted from the 45ft radio telescope at Malvern and received in Texas via reflection from the Moon. In this case, the mean echo amplitude rose gradually to a maximum about 7·5km from the leading edge. Now the Malvern–Texas base-line subtends about $1\frac{1}{2}°$ at the Moon, and consideration of the geometry of reflection for a 5microsec pulse shows that if there is a random distribution of irregularities, as discussed above, this form of echo would be expected.

From experiments such as this it may also be concluded that the Moon would be a satisfactory reflector for communication systems with bandwidths of the order of a few kilocycles per second. A practical point to bear in mind is, of course, the $2\frac{1}{2}$sec delay in sending the signal to the Moon and back.

## Reception of radio-emissions

An important radio-astronomical application of radio telescopes is the study of radio waves emitted by astronomical objects such as radio stars and planets. The signals received from the distant sources are often very weak—sometimes weaker than the increase of the thermal radiation of radio waves from an enclosure

when the temperature rises 1°C—so that very high sensitivities are required.

The following method is applied when a radio telescope is used as a sensitive radiometer. Imagine the aerial is in an enclosure at temperature $T_0$, and suppose noise observed from the receiver is equivalent to an enclosure temperature of $NT_0$. Then $N$ is called the noise factor of the receiver, where $T_0$ is taken as 290° K (normal room temperature).

If $B$ is the receiver input bandwidth, it is permissible to regard the input noise as equivalent to $B$ independent pulses per second. After detection, these are averaged over the output time-constant $\tau$, so the output effectively averages $B\tau$ pulses. Now if $n$ random values of standard deviation $\sigma$ are averaged, the resultant standard deviation is $\sigma/\sqrt{n}$. Thus the fluctuations in receiver output correspond to an input temperature of $\delta T_a = NT_0\sqrt{(B\tau)}$. Suppose $N = 6$, $B = 2$ Mc/s, and $\tau = 1$ sec, then $\delta T_a \simeq 1°$K. To achieve high sensitivity, it is necessary to eliminate variations in the gain of the receiver, and this is done by switching at a sufficiently rapid rate to a standard comparison source.

## Improving sensitivity

The sensitivity can be improved by various devices. For instance, with travelling-wave amplifiers, input bandwidths can be increased to more than 500 Mc/s. An amplifier of this type has been used in conjunction with the 45ft radio telescope to attain a temperature sensitivity of 0·1°K with a 1 sec time-constant; and Fig. 6 shows the radio-emission from the radio source in Cassiopeia obtained with 600 Mc/s bandwidth at a mean frequency of 4000 Mc/s ($\lambda = 7{\cdot}5$cm) as the source passes through the beam. The pattern is essentially that of the beam of the radio telescope, rather less than 20 minutes of arc between half-power points, slightly increased by the diameter of the source, which subtends a few minutes of arc.

Another way of achieving high sensitivity is to reduce the noise factor by using such devices as masers or parametric amplifiers.

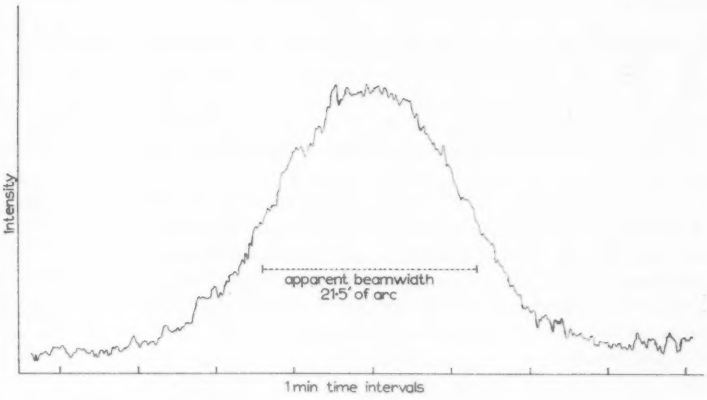
Experimental work has been in progress with such devices, and a maser receiver has recently been used with the 45ft radio telescope. The introduction of highly sensitive receiving devices introduces new problems. For instance, other sources of noise previously ignored become more important, such as radiation from the ground received at the focus from beyond the edge of the reflector, and radiation contributed by connecting cables or guides.

Such difficulties are not all insuperable, and, with ever-improving techniques, radio telescopes continue to make increasingly effective contributions to astronomical knowledge.

**Summary**

The precision of construction of the 45ft radio telescope at the Royal Radar Establishment, Malvern, for operation at centimetre wavelength, is here discussed. Radio-astronomical applications are outlined. Radar observations of Earth satellites and the Moon have been made with a high-power 10cm radar transmitter. The radio telescope has also been used as a radiometer, and sensitive receiving devices have been introduced.

This article is published by permission of the Controller, H.M. Stationery Office.




**6** *Signal received from the radio star in Cassiopeia as it passed through the beam of the radio telescope*

The maximum signal corresponds to an effective temperature at the input to the receiver of about 18° K, wavelength 7·5cm

## Higher transmission voltage in Britain

To reduce the number of high-voltage transmission lines required to meet the growing demand for electricity, the Central Electricity Generating Board are to adopt a 400kV system.

Since most of the existing 275kV lines were originally designed to accommodate a possible conversion to 380kV, these will simply be reinsulated and used for the new voltage where increased transmission capacity is necessary.

New towers are to be introduced for the trunk lines. These will be 20ft taller than existing towers and will carry four conductors per phase, as compared with two per phase at present. Further, they will have an increased power-carrying capacity of 3000 MW.

A new 380kV experimental circuit between Monk Fryston and High Marnham will begin operation in 1962. The first 400kV line should be in use by 1965. Modifications to existing lines will include the substitution of new types of insulator on the existing towers, along with the provision of new transformers and switchgear at terminal substations. 400kV is the highest voltage for commercial purposes outside the Soviet Union.

# Channelling—a sketch

*The Chairman, T. B. D. Terroni, B.Sc., Member, delivered the Address to members of the Electronics and Communications Section on the 26th October 1960 at Savoy Place. Mr. Terroni is with the Automatic Telephone and Electric Co. Ltd.*

Of the carrier transmission equipment which comes within the purview of the telecommunication engineer, the channelling is that part concerned with assembling individual speech circuits by frequency translation so that they form 12 contiguous channels spread over the frequency band 60–108 kc/s. While channelling is generally understood to refer to this basic group adopted by the Comité Consultatif International Télégraphique et Téléphonique, the term will probably still be used when pulse techniques come into general use, although in this case standardization may well be based on a basic-bit group which might, for instance, be made up of 24 channels requiring a digit rate of 1·6 megabauds.

## ADDRESSES OF THE SECTION CHAIRMEN

We present here summaries of the Addresses given by the Chairmen of the specialized Sections at the opening of the present session. It is planned that longer versions of these Addresses will appear in the *Proceedings*

In either case, however, the bulk of the equipment for schemes of any magnitude resides in the channelling, and consequently its development and manufacture can be taken to give a fairly representative cross-section of the work of a telecommunication engineer in industry.

### Basic group

The first problem to be faced by the telecommunication engineer in building up a carrier system is that of deciding how the basic group should be arrived at, and for this purpose consideration is given in the Address to American and European practices and some of the reasons leading to the particular methods employed.

The electrical and the mechanical design are very closely related and were therefore given some prominence in the Address in a brief survey of past and present methods, leading to a somewhat simplified approach to printed-board mounting for transmission apparatus. Recent appearance of British, American and German designs along these lines would tend to point to an inevitable trend in this direction for the immediate future—more particularly so since, with the replacement of valves by transistors, channelling equipment is becoming comparatively speaking inert.

Having reached this point in the development of channelling, it is well to take stock, and it becomes immediately apparent that, if only developments in channelling could go a step further and eliminate the difficulties inherent in frequency-division-multiplex design methods, which require low-distortion amplifiers and filter networks of high frequency-discrimination, manufacture would be easier and less costly, and the economics of telecommunication networks might well take on a new perspective.

### Pulse techniques

A system which would appear to present these desirable features, now that the transistor is available, is one employing the time-sharing pulse techniques which have been discarded up to the present because of the very large number of valves required. Of the pulse techniques available for use on lines, pulse code modulation is looked on as the most promising, and considerable progress has been made in solving the problems involved in sampling, quantization and encoding.

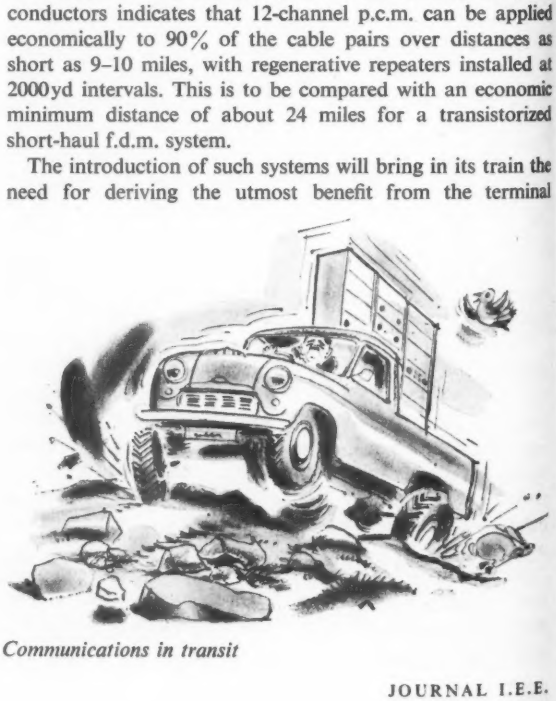
These principles are comparatively unfamiliar to many, and therefore warranted a simple demonstration in the Address of the action of a 3-digit binary encoder, followed by tape recordings to show the effects of quantization on quality of reproduction, with relatively few levels and with a larger number of levels.

To crystallize these thoughts and give them practical significance, the problem of applying 12- or 24-channel p.c.m. to junction cables was next considered. It is felt that congestion in cable ducts in large cities like London and New York has become serious and has created the need for a method of increasing the traffic-handling capacity of existing audio-cable pairs.

### Regenerative repeaters

A study of the crosstalk in junction cables using 20 lb/mile conductors indicates that 12-channel p.c.m. can be applied economically to 90% of the cable pairs over distances as short as 9–10 miles, with regenerative repeaters installed at 2000 yd intervals. This is to be compared with an economic minimum distance of about 24 miles for a transistorized short-haul f.d.m. system.

The introduction of such systems will bring in its train the need for deriving the utmost benefit from the terminal



*Communications in transit*

equipment by extending time-sharing to longer-distance circuits, thereby getting full advantage from tandem operation of regenerative repeaters. This will lead to integration of f.d.m. and p.c.m. systems over the telephone network, which may well include routing through electronic exchanges. The prospects of having a waveguide handling a number of radio-frequency channels, each carrying information at 200 megabauds to convey a 5 Mc/s television channel, a 5 Mc/s f.d.m. system, and seven interleaved 24-channel p.c.m. systems, are no longer quite so remote.

# Developments in electrical plant for industry

*The Chairman, J. M. Ferguson, B.Sc.(Eng.), Member, delivered the Address on the 13th October 1960 at Savoy Place to members of the Utilization Section. Mr. Ferguson is with the English Electric Co. Ltd.*

One of the factors on which the standard of living of an industrial country depends is the productivity of the workers. There is a trend to increase the power available per worker. The cost of electricity has increased less than that of other forms of energy, and therefore there is a strong incentive to electrify industrial plant.

## Motors for electric drives

There are three broad categories of motors for electric drives, namely squirrel-cage induction motors, wound-rotor induction and synchronous salient-pole motors, and d.c. motors. The choice of an appropriate drive is determined by performance, first cost and running costs.

The inherent robustness and lowest cost of the squirrel-cage induction motor make it well suited for constant-speed duty. For a large proportion of industrial drives, variable speed, however, is an essential requirement, and the greatest proportion of variable-speed drives are supplied by d.c. motors.

Static convertors—traditionally, mercury-arc rectifiers and, more recently, germanium and silicon rectifiers—have been used widely where there is no requirement for regeneration. Packaged d.c. drives are readily available up to 100 hp, with automatic speed control using transistor-driven magnetic amplifiers.

## Mercury-arc convertors

In the steel-mill and mining fields, main electric drives must be suitable for regeneration to give the rapid deceleration and reversals necessary, and grid-controlled mercury-arc convertors are being used to an increasing extent. A rectifier is essentially a unidirectional-current device, so that for regeneration or reversal either two banks of rectifiers are used connected back-to-back or a suitable reversing switch is used in the armature or field of the drive motor.

A great deal of effort has been directed towards making the a.c. squirrel-cage motor suitable for variable speed. This, of course, can be achieved by a variable-frequency a.c. supply, but this tends to be uneconomic except for large installations. Any economical method of generating variable frequency would widen this type of application.

Packaged variable-speed drives using squirrel-cage induction motors of small horse-power with speed controlled by series reactors are available. The impedance of the transductor is varied by a d.c. winding controlled from a transistorized d.c.-amplifier stage. Such drives, however, are only suitable for small horsepowers, as the efficiency and power factor fall off markedly at the lower speeds.

## Higher efficiency

New developments of induction motors have been directed towards higher efficiency and greater robustness, but no radically new techniques have been called for. Pole changing has been developed as one solution for a multi-speed induction motor, and a similar result may be obtained with a stator winding of composite coils, separately insulated, equally pitched and connected to give two windings of, say, 8 and 10 poles.

Various forms of squirrel-cage motor of great interest have been described, which can be arranged to give variable speed by physical or electrical shift of the field windings, but these are still under development and not yet in significant operation.

For variable-speed drives the d.c. motor has been largely unchallenged over half a century. This has not led to any startling new developments but rather to a steady evolution in design. Commutation has always been, and still is, one of the most difficult problems, and considerable research effort is being directed towards a better understanding of it. Good progress has been made with the aid of analogue and digital computers to obtain a more rigorous analytical treatment.

## Duplex windings

To obtain a greater output from a given frame size, significant use of various types of duplex windings has been made. Experience has confirmed the advantages of such designs, but, in general, long-term stability for satisfactory commutation has been more difficult to achieve than in the single-lap design.

Modern control schemes have pushed up the rates of change of current in d.c. motors to high values. Solid rolled-steel frames or cast frames cause eddy currents which result in a lag of the flux in the frame behind the current. This lag between flux and current adversely affects the commutation and introduces a delay into the control loop. To eliminate this effect, d.c. machines subject to high rates of change of current are constructed from laminated frames.

## Control schemes

With the pressure to speed up output for a given plant or process, the design of the control scheme becomes more and more important, and increasingly the responsibility of the driver to obtain optimum and consistent results is being taken over by the control scheme. It is now possible to completely

control complex equipment in accordance with prepared programmes contained on a punched card, tape or other source of stored information.

Parallel development of high-speed digital computers has now also reached the stage when serious consideration may be given to the control of equipment, not only from stored information, but also from up-to-date information and data which can be processed at high speed and used to modify or optimize the process in a time that could not be achieved by a human operator. It is prudent, however, to be quite certain in each case that the increased complexity will bring a sure and adequate reward.

# The developing engineer

*On the 19th October 1960, the Chairman,* ***J. E. L. Robinson, M.Sc., Member,*** *delivered the Address at Savoy Place to members of the Supply Section. Mr. Robinson is with Associated Engineering Ltd.*

I AM concerned with three interpretations of my title—the developing position of the engineer in society, the growth in outlook of the individual engineer, and the engineer engaged in the development of his product.

## Three aspects

The rapid growth in the number of scientists and technologists in the universities and technical colleges presages the increasing impact which they will have on society in the generation ahead. This lends emphasis ever more strongly to the already apparent need for developing these men more fully on the humanistic side. Although to this end much thought is being devoted to augmenting the later stages of technical training, I think this does not go far enough, and that it is in the later school years that the main changes must be made. The degree of specializing there should be reduced to make way for the continuance of a generous proportion of humanistic studies up to the leaving age.

On the second aspect, I am aware of a new outlook, dating from about the war period, on the potentialities of technical development and of the taking root in our philosophy of the concept of the 'break-through'. With the lesson of recent striking developments in mind, it behoves us to look afresh at our more traditional equipment and examine how much farther ahead the path of its development can be discerned.

This leads to the third aspect of my title, and the first thing to consider are our basic materials, magnetic, insulating and conducting. In the sense that, apart from overvoltage conditions, it is practicable to operate large transformers within 10% of the ultimate saturation density, the magnetic material is perhaps the most advanced, but there is much to be done yet to reduce magnetostriction and hysteresis loss.

## Superconductivity

The traditional impregnated-paper insulation has had a remarkable innings but is an imperfect dielectric and must eventually be superseded, so that higher operating stresses will become possible. For the conductor, we are at first sight stuck with the limitations of copper or silver; but surely there is reason to hope that we can get round the difficulty by operating in superconductivity conditions and, in the process, avoid the unsatisfactory compromise which requires conventional insulation to be at the same time good electrically and bad thermally.

The economic solution of high-voltage d.c.-to-a.c. conversion will eventually be found with the aid of semiconductors or otherwise, and this and dielectric developments can be expected to transform cable economics and oust the overhead transmission line. It may well be that the same developments will also solve the high-power circuit-breaker problem.

## Insulated foil

In electromagnetic equipment, it is arguable that the generator has approached nearer its ultimate than has the transformer, and the latter, with conductor space factors on large units of the order of 20%, can surely be drastically improved. Search for how this can be achieved leads to the concept of windings made not of wire but of insulated foil of width almost equal to the full-leg length of the transformer.

Such a winding has a large and linear series capacitance, which gives it a uniform impulse distribution and leads to all the interturn and major insulation being uniformly stressed in both working and impulse conditions. This, in turn, requires the minimum possible volume of insulation. Other advantages are that current is free to dispose itself in the windings for perfect ampere-turn balance, and no over-all axial mechanical forces arise. The thin foil practically obviates radial and end eddy-current losses. Cooling ducts are simple unstressed axial channels, and forced coolant flow is superimposed readily on the natural thermo-syphon action.

The application of this method, however, poses new problems of how to provide the several acres per transformer of sufficiently pure insulation of a few mils thickness, and how to fix the whole together. It does, however, open up the ultimate possibility of manufacturing transformer windings by electroplating the foil to the required width and thickness at the time of winding, and coating it with insulation and forming the complete winding with major insulation and tapping sections all in a continuous operation. For a given rating, a reduction in weight to 40% of present values seems feasible, or for the same weight a fourfold increase in rating.

## Assembly on site

A further development would be the enclosure of the windings of each leg in close-fitting cylindrical metal tanks constructed with insulating seams and provided with individual oil-cooling systems. A large transformer could be assembled on site from three such units and an enclosed core, also with its own separate cooling system. Only this last would have to be interfered with in field conditions. This would open the way to providing transformers of several thousand megavolt-amperes rating.

# Time and insulation

*The Address was delivered by the Chairman, **C. G. Garton**, Member, to members of the Measurement and Control Section on the 11th October 1960 at Savoy Place. Mr. Garton is at the Electrical Research Association Laboratory.*

THE subject of insulation is not obviously within the scope of the Measurement and Control Section, but although all four Sections of The Institution deal with insulation problems peculiar to their own activities, the general theory of dielectric materials is, perhaps rather arbitrarily, classed together with measurement. An Address on the physical background of insulation seems appropriate at this time, when the great expansion of the electronics field has imposed on insulation conditions and requirements, especially as regards temperature and reliability, which go far beyond the demands originally made on insulation for power purposes.

## Extreme reliability

New requirements as regards temperature arise from the more varied environments in which insulation must now operate. It may be exposed to extreme cold in satellites or to high temperatures in nuclear reactors. Pump motors for reactors have actually operated with their windings immersed in liquid at 450°C. Reactor-core temperatures of 1500°C are envisaged, and problems of electrical control and measurement at these temperatures arise.

Similarly, demands for extreme reliability arise both from new environments and from the extreme complexity of some electronic apparatus. Insulation may be required to operate for long periods with no possibility of a single failure when it is installed in such inaccessible places as a satellite in permanent orbit or in a submarine telephone repeater at a depth of perhaps 10000ft. The number of components in a large computer may be of the order of a million, so if the probability of failure in any given component were as great as once in 20 years, and the failures occurred at random over this period, the operation of the computer would be interrupted every few minutes.

## Intuitive feeling

To meet such requirements, the insulation engineer can no longer rely on the conventional tests and knowledge of insulation behaviour which have served for less stringent needs. It is important to develop ways of thinking about insulation which give an intuitive feeling for the behaviour of matter at temperatures and over long periods which are outside the range of direct human experience.

The high-voltage capacitors in a submarine telephone cable require an average life in their working conditions of the order of $10^4$ years in order that no single one of them shall fail during, say, 30 years' life of the cable. On the other hand, a process of deterioration which occupies thousands of years at the temperature of sea-water may take place in a few seconds if the temperature is raised to 300° or 400°C.

There is, however, a unifying concept which makes it easy to understand the very great dependence of properties on temperature, and which also unifies the theory of very diverse processes, so that similar methods of thought can be used for the majority of properties, both electrical and mechanical, of many materials. This is the concept of the rate process.

## Nature of rate process

The nature of the rate process can be most easily understood by considering why chemical or physical processes, which it is known will reach completion after a longer or shorter time, do not go to completion instantly. The reason is that the atoms or molecules in any system which is not in an extremely rapid state of change occupy the positions which they do because they have found at least temporary positions of minimum energy in the structure, and cannot leave these positions until by some means they acquire sufficient energy to pass over an energy barrier to a new position of lower energy than the first one.

Since most external causes of change, such as an electric field or a moderate mechanical stress, cannot supply anything like this amount of energy to an individual molecule, the only occasion on which the molecule can make the transition described above is when it receives by chance an altogether exceptional proportion of the random thermal agitation which is distributed throughout the system.

## Mathematical expression

This idea can be expressed mathematically by saying that in a simple rate process the rate of change will be governed by a characteristic time:

$$\tau = \tau_0 e^{W/kT}$$

where $\tau_0$ is a constant, $W$ is the energy required to enable a molecule to make a transition, and $kT$ is the thermal energy, which at room temperature is about 0·025eV.

This simple equation underlies nearly all the changes, electrical, mechanical and chemical, to which insulation is subject. A great deal can be deduced from it almost without knowledge of the particular material or particular process. For example, the fact that many processes in insulation about double their rate for every 10°K increase in temperature can be deduced immediately. The temperature interval required to alter the rate by a factor $\varepsilon$ (2·718 . . .) is:

$$T_c = \tau \mathrm{d}T/\mathrm{d}\tau$$

and, by differentiating the expression for $\tau$, this can easily be shown to be:

$$T_c = kT^2/W$$

Although $W$ is not known exactly until the material and the process are specified, its order of magnitude is known, because materials for which $W$ is much less than 0·5eV will change so quickly as to be of little practical use, while few materials have $W$ as large as 5eV. Thus $W$ cannot be very far from 1eV, which, together with the known value of $k$ (about $8 \times 10^{-5}$eV/degK) and $T = 300$°K, gives $T_c \simeq 7 \cdot 2$°K.

# Talking about science 5(042)

*This is an account of the principles that the author feels must be observed if communication about science is to be achieved at various levels. The article is based on a lecture given to the Electronics and Communications Section at Savoy Place on the 27th January 1960 (see March 1960 Journal, p. 192). Dr. Clow is the senior member of the B.B.C. Science Unit which is responsible for the production of science talks in the Corporation's domestic services.*

**ARCHIE CLOW**, M.A., D.SC., F.R.S.E.

An outstanding present problem, broadly in the field of communication, is to find means of conveying to ordinary intelligent persons in intelligible terms the facts and ideas of science. This is a problem on which relatively little research has been done, and it is not surprising that, in view of the extent to which radio and television reach mass audiences, most of the investigations have been initiated in relation to broadcasting. Some surveys have been undertaken in an attempt to discover what characteristics in a radio script promote maximum intelligibility.

The researches referred to are in no sense profound or comprehensive. The most they can be said to do is to pinpoint certain characteristics in the presented material that help the listener; they also emphasize that in communicating about science in all media it is the limited intellectual capacity of the audience that is one of the most significant controlling factors.

At different levels this gives a common denominator to writing, lecturing, broadcasting, and television, so it may be profitable to look in greater detail at some of the features that affect intelligibility under such headings as range of vocabulary, sentence structure, scientific jargon, and so on. What follows is largely based on experience in radio editing, but what is said can be generalized and applied in any medium in which science is presented.

## The common vocabulary

A significant and revealing study of vocabulary in relation to scientific communication, particularly the presentation of 'popular science', was published in 1957 by W. E. Flood of Birmingham.* Flood asserts that in the course of his school career a child builds up a vocabulary of about 5000 words. Some of these are 'scientific' in the sense that such words as pressure, temperature, force and ray are scientific, while at any one time the vocabulary will include a smattering of vogue words of scientific origin, often wrongly used, like allergy and supersonic.

Clearly one cannot go very far in scientific communication with these 5000 words, and to demonstrate their limitations it is instructive to look at 'The teacher's wordbook of 30000 words', which was prepared by its authors on the basis of an examination of 2 million words of average reading matter.* We find that we have to extend the vocabulary to 6000 words to include telescope and thermometer; to 7000 words for magnet, eclipse and filter; to 8000 for lens and protein; to 9000 for parasite and protoplasm; and it is not until we reach 10000 that we include calorie and carbohydrate.

That is to say, some 5000 words are used by all ordinary people, between 5000 and 10000 are known to a wide range of listeners, but beyond the 10000 mark there are many words necessary for scientific communication that are not known by the majority of any mass audience. This means that even at secondary-modern level serious difficulties arise.

Flood himself carried out tests on secondary-modern pupils (aged 14–15) to ascertain what they knew of the words of science. While 90% knew 'aerial' only 52% knew 'alternating current'; 95% knew 'valve' but only 59% 'circuit'. Only 62% had encountered 'generator', and other electrical devices were even less familiar: 'insulator', 55; 'resistance', 49; 'cell', 47; and 'magnetic pole', 42%.

Depressing though these results may be to electrical engineers, some basic words of chemistry were even less familiar. For example, while 90% (perhaps not surprisingly) knew 'atom', only 32% knew 'element' (chemical).

No figure was given for 'satellite', but at the time of the investigation some years ago the score for 'orbit' was 18%.

In my own mind there is no doubt that these figures approximate to the true state of affairs, because within my own experience I discovered that while 95% of an audience knew that some diseases were caused by 'germs', and 80% had heard of Pasteur, only 50% knew that beer was produced by fermentation, and 5% that milk soured as the result of bacterial activity.

## Use of available vocabulary

It is now appropriate to refer to ways in which words can be deployed. These comments are based on more than 12 years' activity involving the preparation of material for broadcasting, supplemented by the accumulated experience recorded in S. G. Gray and B. E. Leary 'What makes a book readable' (University of Chicago Press, 1939); R. O. Kapp 'The presentation of technical information' (Constable, 1948); and J. W. Godfrey and G. Parr 'The technical writer' (Chapman and Hall, 1959); plus the findings† of researches carried

* FLOOD, W. E.: 'The problem of vocabulary in the popularisation of science' (Oliver and Boyd, 1957)

* THORNDIKE, E. L., and LORGE, I. (Columbia University, 1944)

† TRENAMAN, J.: 'Intelligibility of educational broadcasts', *Nature*, 1950, **166**, p. 814

'Understanding radio talks—a BBC experiment', *Adult Education*, 1950, **23**, p. 176

VERNON, P. E.: 'The intelligibility of broadcast talks', *BBC Quarterly*, 1950-51, **5**, p. 206

out on behalf of the B.B.C. by P. E. Vernon and J. Trenaman.

A marked deterrent to easy communication is the long involved sentence, often with misplaced clauses possibly referring to different antecedents, and unattached participles. In a praiseworthy attempt to be precise an author may overcondense, and this brings its own attendant dangers, as in 'A beaker of helium empties itself by flowing up and over the rim and dropping off the bottom'. Such infelicities can best be avoided by a cultivated awareness involving among other things attention to the position of clauses, particularly those of time, and the alternation of long and short sentences to give a crispness to style.

But even with all the clauses in their right places and the lengths of the sentences adjusted to a point of finesse, much that is undesirable can still be left inside them. An example is what may be called 'dignity words and phrases'—words and phrases selected and used because the author believes that they add grandeur to his prose. In good spoken-word English especially, such elegant variations are better eliminated, because they give an unwanted stiltedness to writing that after all is supposed to simulate the spoken word. Common, though not particularly offensive, examples are:

| | |
|---|---|
| composed of | = made of |
| method | = way |
| in the region of | = about |
| of the order of | = about |
| subsequent to | = after |
| in a few instances | = occasionally |

## Pomposity and precision

An extension of the misguided selection of dignity words is the really objectionable resort to straightforward, if presumably unconscious, pomposity. If the perpetrators of the following had first considered what they were going to say, I do not doubt that they would have said it otherwise: 'For the procurement of further data . . .'; 'The cell became 50% deoxygenated'; and that superb example given by Godfrey and Parr, 'There may be a protracted hiatus in providing potential at the consumers' terminals'.

Much writing of this kind—and the journals are full of it—would be avoided if the author, having brought forth, took pains to consider what he had produced. This is also true with respect to the precise meanings of words. You do not have *three* alternatives; a *protagonist* is not the opposite of an *antagonist*, and you can only have one of them; the relatives *that* and *which* are not synonyms (roughly, *that* introduces defining clauses, *which* does not). Then there are words that give an ambiguous start to a clause—often rapidly corrected it is true, but nevertheless putting unnecessary strain on the listener. *For* and *since* may mean *because* but not always. If you mean *because*, why not say *because*?

A common misconception, bred I fear in the English classroom, is that it is undesirable to repeat words. In certain circumstances this may be true, but to avoid doing so in spoken-word English, by, for example, the use of former and latter, is to increase unnecessarily the possibility of failing to communicate clearly. Pressed to the extreme, how ridiculous their inappropriate use can be is illustrated succinctly by '$x$ plus $y$ squared equals the former squared plus the latter squared plus . . .'. Similarly, the over-use of pronouns may cause misunderstanding—far better repeat the noun.

A particularly irritating usage that has crept in, and is increasing, is the adjectival-noun construction. J. R. Baker of Oxford wrote wittily about this in *Nature* and quoted a prime example: an adenosine triphosphate activated actomyosin contraction.

Much scientific communication lacks directness because scientists are by training cautious. But the persistent use of the subjunctive in the interests of methodical doubt induces unnecessary woolliness. Similarly, the present tense can often be substituted for the future with a gain in clarity. The active voice is generally more dynamic than the passive.

## Jargon

So far I have said nothing about one of the commonest complaints against scientists—their use of what is usually referred to as 'scientific jargon'. In spite of St.J. Gogharty's remark that 'Stone walls do not a prison make, but scientific terms do', it is my belief that the matrix is every bit as important as the technical terms embedded in it. Clearly, technical terms cannot be avoided, but they can often be made clearer by the use of negative interpolations, and, particularly when communicating with a lay audience, it is helpful to give derivations of the less-familiar terms used. These may be either classical derivations or explanations of the neologisms of physics, such as 'muon'.

One should look out for portmanteau words like 'occur'. I have not readily forgotten an examinee's answer to 'Describe the occurrence of chlorine' which read: 'Chlorine occurs at the top right-hand corner of the Periodic Table'.

## Clichés

Another pitfall for the speaker who has not a fully conscious grasp of his material is resort to cliché. There is nothing inherently wrong with many of the phrases now so classified; what is wrong is that they have lost meaning through pointless repetition. One that particularly incensed Quiller-Couch was 'in the case of . . .'; yet many lectures contain enough cases to fill a warehouse. Overworked phrases are always with us; as one loses favour, another takes its place. Recently we have had a spate of 'break-throughs' and 'new fields to explore', and new ones are doubtless germinating in the literature.

An amusing glossary of phrases used in scientific papers and their alleged real meanings was published in the house journal *The Link* and reprinted in part in the

*Journal of the Institute of Biology*. Many of them raise a laugh because they are wittily malicious, for example 'it has long been known' = 'I haven't looked up the reference'; but is it not often true that 'it is suggested that', 'it is believed that', and 'it may be that' all really mean '*I* think', while 'it is generally believed', means '*we* think'?

A careful scrutiny of the full list will almost certainly bring a blush of shame to everyone who has written a scientific paper.

### Desk aids

While this short article is primarily related to oral presentation, what is spoken has often subsequently to be prepared for the Press. It is therefore not inappropriate to mention a small number of publications, familiarity with which on the author's part would frequently save editors a great deal of trouble.

Applicable to all literary work and invaluable in increasing that awareness to which reference has been made are H. W. Fowler, 'Modern English usage'; E. Partridge, 'Usage and abusage'; or the less elaborate works of Ernest Gowers.

Of particular use in the preparation of a manuscript are H. Hart, 'Rules for compositors and readers at the University Press, Oxford'; F. H. Collins, 'Authors' and printers' dictionary'; and, for the scientific paper, the 'Notes on the preparation of papers' adopted by the Royal Society, and the 'Notes on the preparation of illustrations' issued by *The Biochemical Journal*.

All who write should be aware of the existence of B.S. 1219: 1958, 'Printers' and authors' proof corrections'.

This list is, of course, in no sense exhaustive. All it pretends to do is point out some valuable aids in the mechanics of authorship.

### Summary

At present, interest in science is high. It is therefore not difficult to assemble an attentive audience. What we have to make an additional effort to achieve is an understanding audience. Any literary or artistic device that increases intelligibility is worthy of consideration.

So far as sound broadcasting is concerned, the following points have been shown to be of special importance. One must start by having something worth while and interesting to say; the lay-out of the material must be so contrived that the attention of the audience is seized and held during the first vital 30 seconds of the talk. But no audience is held for long if interest flags, so a continuous effort must be made to keep the ideas flowing and the treatment imaginative, and this right to the end of the broadcast. Then, just as the opening is important, so the end deserves particular consideration.

With regard to delivery, it is my belief that in the final analysis a lecture or a radio talk is a performance and that some modest showmanship is not entirely out of place.

Lastly, have no fear about being over-simple. There is profound wisdom in Sir Edward Appleton's remark that 'If you cannot explain your work in simple language you haven't got to the bottom of it yourself'.

---

# Confidence in electronic switching for telephones

## INSTITUTION CONFERENCE ON ELECTRONIC TELEPHONE EXCHANGES, 22nd–24th NOVEMBER 1960

That electronic telephone exchanges are now technically practicable was the main conclusion of the international conference on electronic exchanges held at Savoy Place from the 22nd to 24th November 1960. The conference was clearly a success and must certainly be repeated in due course.

The international character of the conference was much in evidence, with visitors from many European countries, Japan and the United States. Many of these visitors presented papers; over one-third of the papers were by foreign authors and, together with the British papers, provided a thorough coverage of the subject.

### Stored programme control

The main themes of the conference seem to have been confidence in the future of electronic switching in the telephone network, a growing emphasis on the need for system reliability which must be maintained even though faults occur, a thorough appreciation of the importance of economic studies, and a growing awareness of the need for electronic switching systems to contain the means for adapting them readily to meet the future needs of customers. Several authors discussed the adaptation of data-processing techniques to the control of switching networks, mostly under the heading of stored programme control of exchange connecting apparatus.

It seems clear that this approach to system design will need much careful appraisal in the immediate future because of its undoubted power to provide the maximum flexibility in introducing new facilities and its ability to add to these facilities rapidly without modification of the equipment and its wiring. Many hearing about stored programme control for the first time must have gone away in a thoughtful frame of mind, and it seems inescapable that more will be heard of this during the next few years.

Confidence in the ultimate success of electronic switching was expressed by several speakers, tempered naturally by caution as to when and by what method; but confidence nevertheless.

The first electronic exchange—a space-division system using gas-tube crosspoints and stored programme control, sponsored by the Bell organization in the United States—is already in public service at Morris (Chicago), and commercial

production of electronic exchanges is planned to begin in the United States during 1965. One or perhaps two other electronic exchanges—also space-division exchanges—using dry-reed relays as crosspoints with electronic controls are planned for public service in the German P.T.T. network within the next two years. In Britain, the Highgate Wood experimental time-division electronic exchange is due to be ready for public service by 1962; this will be the first time-division exchange to be so used.

### Reliability and economics

Reliability was discussed by several authors and speakers. The special need for telephone networks to give continuous service 24 hours a day and seven days a week was clearly appreciated, but there were fairly large differences of opinion as to the best means of ensuring this.

On the one hand the view was expressed that component reliability allied with automatic fault location and correction would soon provide a satisfactory answer; on the other was the view that the system should be made reliable by making it continue to give a satisfactory service by providing sufficient equipment redundancy in the system organization. Redundancy would present a measure of alternative routing through the exchange equipment to enable a faulty unit to be avoided. This is clearly a key issue.

As might have been expected, economics received frequent attention. It was perhaps in this field where the experts were least confident—not in the ultimate outcome but on when and how economic parity with existing systems might be achieved. A paper on the economics of electronic exchanges would have excited considerable interest and, without doubt, a vigorous discussion; and the next conference should if possible encourage the presentation of material on this topic.

There was an entertaining discussion on the new customer facilities offered by the Morris electronic exchange. This indicated clearly that stored programme control not only provided new customer facilities easily, but also, because of its flexibility, offered an opportunity for others, not previously defined, to be incorporated readily without modification of the equipment. There was, however, clearly some undercurrent of disagreement as to whether the economic implications of a thoroughgoing stored-programme-control system could be justified for the many thousands of small exchanges throughout the world.

### Semiconductor crosspoints

The session on space-division exchanges produced some lively discussion on the pros and cons of semiconductors as crosspoints. Transmission performance and cost appeared to be obstacles that needed further study. The chief contender as a crosspoint, the dry-reed relay, received a measure of support, but it was clear that many regarded the dry-reed device as being at the best a quasi-electronic component and therefore slightly disreputable from the purist's point of view.

The final session covered a wide range of subjects. First came a glimpse of the possible future in the form of an integrated system of traffic concentrators in the local line plant network and time-division switching through centrally located switching units. This was followed by a description of apparatus for stored-programme-controlled switching systems; an account of a new method of assessing traffic capacity using a commercial computer, ably supported by a film illustrating the computer action; explanations of new types of telephone using tone ringing instead of a bell, and voice-frequency signalling; and finally a provocative paper on the planning of future networks that include electronic exchanges, which held out the prospect of a general improvement in transmission.

The material was in general of a high standard; but, as many papers dealt with system designs, the authors, in the time allotted to them, could do little more than outline the principal features of their systems. This inevitably introduced an element of monotony not conducive to active discussion.

### System comparison

In organizing the presentation of the material it must have seemed natural to group papers under common subject headings, e.g. time-division systems and space-division systems. In retrospect, it seems that this may have prevented the development of discussion on system comparisons, particularly around the well known controversy of space division versus time division; a future conference, supported by field experience, might well benefit from a judicious mixing of material to stimulate discussion on design philosophy. Alternatively, a session might be devoted entirely to discussion.

It was also clear that none of the authors was prepared to disclose his more advanced thinking, particularly on system-design philosophy. Papers on this aspect may in fact have to wait for some time yet. Nevertheless, despite the criticism of the presentation, the conference was first-class; worthy of special mention in this respect was the excellent presentation from the oversea visitors, many of whom displayed an impressive mastery of a foreign language, not only in presenting the material itself but also in the subsequent discussion. Noteworthy also was the effective use of coloured slides by the visitors.

The cocktail party following the final session on the 23rd November was well attended, and the opportunity it offered for informal discussion was much appreciated and well used. On the 24th November, there was an organized and well patronized visit to the Post Office Research Station at Dollis Hill to inspect the working model of the Highgate Wood electronic exchange.

### A success

The conference was a success and must be repeated. The attendance was over 600, with 123 oversea visitors. It had the generous co-operation of the British Post Office and of the British telephone-equipment manufacturers and widespread support from industry at home and abroad. The main impression is that it was worth while and appreciated by all who attended; and, despite the criticism that has been offered, The Institution can be satisfied that it has fulfilled a need at a most opportune moment.

C. E. CALVELEY

## X-rays for nuclear power stations

A 4·3 MeV linear accelerator has recently been delivered to the U.K. Atomic Energy Authority. Designed to make X-ray examinations of pressure vessels in nuclear power stations during construction, the machine is the first completely mobile linear accelerator in the world.

It will enable the welds in the thick steel walls of the pressure vessel containing the reactor cores to be radiographed on site with a minimum of disturbance to construction work. The unit weighs two tons, and will be first used at the 500 MW Trawsfynydd station now being built in Merionethshire, Wales, for the C.E.G.B.

# LETTERS TO THE EDITOR

## *THE DEFINITION OF ELECTRIC CURRENT*

Dear Sir—Is it not unfortunate that many engineering students seem to regard the Kirchhoff formula $i = \mathrm{d}q/\mathrm{d}t$ as the only definition of electric current? This formula represents what may be called the 'turnstile' idea of the measurement of electric current: one sets up a turnstile or road-block at some point in a circuit and counts the electrons (or ions) as they pass by a given point. In any case this is quite unrealistic, since ammeters, whether electromagnetic or thermal, depend on the effects produced by the passage of current over very appreciable lengths of conductor.

On the other side, students tend to think of displacement current in terms of Faraday's model of displacement of charges in a dielectric; yet, as Moullin has pointed out,[1] 'But all this is just a model which must not be allowed to restrict thought. Faraday's conception of current was very wide . . .'.

The shift of attention back from circuits to fields, which is required for many modern problems, reintroduces *current density* as the basic quantity, and displacement current in the Maxwell sense then fits in naturally. For there are two arguments that the sum of conduction/convection current density and displacement current density forms a distinct entity, having the characteristic that its divergence is zero and therefore it is representable by a solenoidal vector. In everyday terms, there are neither sources nor sinks of this joint quantity $\boldsymbol{J}_c + \mathrm{d}\boldsymbol{D}/\mathrm{d}t$.

The first is a generalization of the 'Kirchhoff' argument. Let a volume $V$ bounded by a surface $S$ contain charge $Q$ which is, in fact, distributed so that $Q = \int_V \rho \mathrm{d}v$. The current flowing out of the volume is measured as an integral, over the bounding surface, of current density; this may be equated to loss of charge, and charge related by Gauss's theorem to surface integral of $\boldsymbol{D}$:

$$\int_S \boldsymbol{J}_c . \mathrm{d}\boldsymbol{a} = -\frac{\mathrm{d}}{\mathrm{d}t}\int_V \rho \mathrm{d}v = -\frac{\mathrm{d}}{\mathrm{d}t}\int_S \boldsymbol{D} . \mathrm{d}\boldsymbol{a} \quad . \quad . \quad (1)$$

Then it follows from $\int_S \left(\boldsymbol{J}_c + \frac{\mathrm{d}\boldsymbol{D}}{\mathrm{d}t}\right) . \mathrm{d}\boldsymbol{a} = 0$

that $$\int_S \mathrm{div}\left(\boldsymbol{J}_c + \frac{\mathrm{d}\boldsymbol{D}}{\mathrm{d}t}\right) \mathrm{d}v = 0$$

and it is usually assumed (without conflict with experiment) that div $(\boldsymbol{J}_c + \mathrm{d}\boldsymbol{D}/\mathrm{d}t)$ vanishes everywhere.

The second argument is that as an experimental fact curl $\boldsymbol{H} = \boldsymbol{J}_c + \mathrm{d}\boldsymbol{D}/\mathrm{d}t$. The right-hand side of this equation is therefore (a) a quantity which, in general, plays the part played by $\boldsymbol{J}_c$ at sufficiently low frequencies, and (b) a quantity having zero divergence.

Many well known books[1–4] concur that it is convenient to regard 'current density' in its most general terms as a solenoidal quantity equal to $\boldsymbol{J}_c + \mathrm{d}\boldsymbol{D}/\mathrm{d}t$. Certainly it is convenient to do so when analysing fluctuation currents arising from the movement of electrons;[5,6] for it is then possible to define the current which results from the movement of a free charge between electrodes.[7–9]—Yours faithfully,

D. A. BELL, MEMBER

Reader in Electromagnetism
Electrical Engineering Department
University of Birmingham
Edgbaston, Birmingham 15

2nd December 1960

1 MOULLIN, E. B.: 'The principles of electromagnetism' (Oxford, 1955), 3rd edition
2 ABRAHAM, M., and BECKER, R.: 'The classical theory of electricity and magnetism' (Blackie, 1950), 2nd English edition
3 JEANS, SIR JAMES: 'The mathematical theory of electricity and magnetism' (Cambridge, 1925), 5th edition
4 HARNWELL, G. P.: 'Principles of electricity and electromagnetism' (McGraw-Hill, 1949), 2nd edition
5 BAKKER, C. J., and DE VRIES, G.: *Physica* (The Hague), 1934, **1**, p. 1045
6 BELL, D. A.: 'Electrical noise' (Van Nostrand, 1960)
7 VON ENGEL, A., and STEENBECK, M.: 'Elektrische Gasentladungen', Vol. 1 (Springer, Berlin, 1932)
8 SHOCKLEY, W.: *Journal of Applied Physics*, 1938, **9**, p. 635
9 RAMO, S.: *Proceedings of the Institute of Radio Engineers*, 1939, **27**, p. 584

## *JUNCTION TRANSISTORS AND THEIR APPLICATIONS*

Dear Sir—It is hard to produce a clear yet concise explanation of the operation of a transistor, since this involves many unfamiliar or even new ideas for the engineer, although not for the physicist. To obtain conciseness, the physicist has defined certain concepts by giving them names, e.g. electron and hole.

Mr. O. D. Robinson (October 1960 *Journal*, p. 598) has already been answered in some detail on the subject of electrons and holes by Mr. E. Wolfendale in the February 1959 *Journal*, p. 106, and the November 1960 *Journal*, p. 648. As Mr. Wolfendale says in his first letter, without going more deeply into the physics it would be difficult to carry this explanation further. However, some further remarks on the 'carrier' may be helpful.

Current is the rate of flow of charges, and in semiconductors these charges can be either positive or negative. 'Carrier' describes something which carries charge, whether positive or negative, so in a semiconductor this can mean either a free electron or a hole. Note that this is a free electron; 'carrier' does not apply to an electron which is not free to move, i.e. free to transport charge. Holes are essentially mobile charge carriers. 'Carrier' is then a useful general term by which certain properties may be described, e.g. minority carriers may be either free electrons in *p*-type material or holes in *n*-type material, which have similar properties.

Mr. Robinson seems to question other points of widely accepted terminology. Potential barrier means a barrier formed by charges, these charges creating a potential, and it does prevent further flow of charges. It is not, however, just like a resistor or an insulator, since the passage of charge across the barrier is an exponential function of the applied voltage.

The input and output circuits are correctly referred to as impedances because they are frequency-dependent, and they do vary with the particular arrangement adopted.

Gain is an accepted term meaning the ratio between an output quantity and an input quantity, and it can be positive, negative, fractional or even complex. This prevents the anomalies which would arise if a gain of say 2 changed to some other quantity as it became unity, and still another as it became less than one! As gain is a ratio, the answer to the question '50 what?' is 'just 50'.

These terms are the accepted, familiar names used by engineers who deal regularly with these devices. They define groups of facts or concepts and are useful to anyone following, or working on, the subject; they are not merely esoteric synonyms.—Yours faithfully,

J. A. CHANDLER, GRADUATE
Associated Electrical Industries (Rugby) Ltd.
Research Laboratory
6th December 1960 Rugby, Warwickshire

## *CYCLES OR HERTZ*

Dear Sir—Referring to the proposal contained in the letter from Mr. W. H. P. Leslie on p. 648 of the November 1960 *Journal*, that the term 'hertz' should be adopted in Britain to replace the conventional 'cycles per second', I would strongly deplore any such change.

It was one thing to commemorate the pioneers of electrical science by using their names to designate the various units where an identifying word of some sort was imperative—e.g. Ampère, Volta and Ohm (but what a pity it was that usage had to abbreviate two of these to 'amp' and 'volt'). It is quite another matter to employ a proper name to designate something which isn't a unit at all, particularly when that 'something' can be so briefly described in 'common or garden' English as 'cycles per second'.

No one has ever suggested that police prosecutions for exceeding the 30 m.p.h. speed limit should charge the offender with exceeding 'thirty campbells'.

Much as one honours the name of Heinrich Hertz, I can see no possible justification for attaching his name to something which can be more logically and understandably described in plain and simple English.—Yours faithfully,

G. R. M. GARRATT, MEMBER
Science Museum
24th November 1960 South Kensington, London S.W.7

Dear Sir—The suggestion that the name Hertz (h or Hz) should be used as a replacement for cycles/sec or pulses/sec has now appeared in the correspondence columns of several technical journals. In opposition, British Standards Institution recommendations have been quoted, but this seems insufficient, as the recommendations could be revised if there were sufficient justification and demand for the change.

I would like to suggest further objections to the adoption of the name Hertz.

It contains no information about the dimensions of the quantity to which it refers, whereas cycles/sec, pulses/sec (besides being largely self-explanatory) indicate a dimension of $(\text{time})^{-1}$.

It seems desirable to keep the number of units to the practical minimum and make them as 'fundamental' as possible. To take two examples, consider the unit of force and the unit of flux. It would be preferable to use the kg-metre/sec$^2$ rather than the newton, but the use of the newton is, of course, desirable on the grounds of brevity. The justification for the weber is more doubtful; 'volt-sec' is no more cumbersome and has, in fact, been used in some textbooks (e.g. 'Electrical fundamentals', H.M.S.O.).

The adoption of the hertz would add just one more to the already large number of different units in use, without any advantage in brevity.

The verbal use of 'cycles' is surely reasonable on the grounds that the second is, in this context, always used as the unit of time. When conversing with engineers accustomed to measuring frequencies in cycles/min or cycles/hour, it would obviously not be permissible to use the expression 'cycles' to mean cycles/sec.—Yours faithfully,

A. C. DAVIES, STUDENT
Greenbanks
15 Town Lane
28th November 1960 Sheet, Petersfield, Hants

## *BRITAIN'S ENGINEERING MANPOWER*

Dear Sir—The leading article on p. 625 of the November 1960 *Journal* gives interesting and important statistics about the number of technicians in the United Kingdom and the United States. The Institution has also concerned itself with their training.

For some time, I have felt that the status and national importance of technicians have been insufficiently realized. It must be a common experience for engineers to find themselves undertaking or asking others to undertake routine calculations or designs, a function proper to a technician under the general guidance of a professional engineer.

It has been suggested, and I think it sound, that there should be about three technicians to every professional engineer. Would it not be appropriate for The Institution to sponsor the cause of technicians by proposing a Royal Society of Technicians with examination, practical training and responsibility qualifications? With modern trends of integration, perhaps a Royal Society of Electrical Technicians would be unwise. A society to embrace technicians in all the major industrial technologies—electrical, mechanical, civil, structural, aeronautical, marine, etc.—would have great strength and importance. Membership could be Student (S.Roy.S.Tech.), Associate Fellow (A.F.Roy.S.Tech.) and Fellow (F.Roy.S.Tech.).

Would it not be a national advantage and in the spirit of its Charter of advancing knowledge if The Institution joined with other Institutions to found such a body and offer it the hospitality of the House of The Institution?—Yours faithfully,

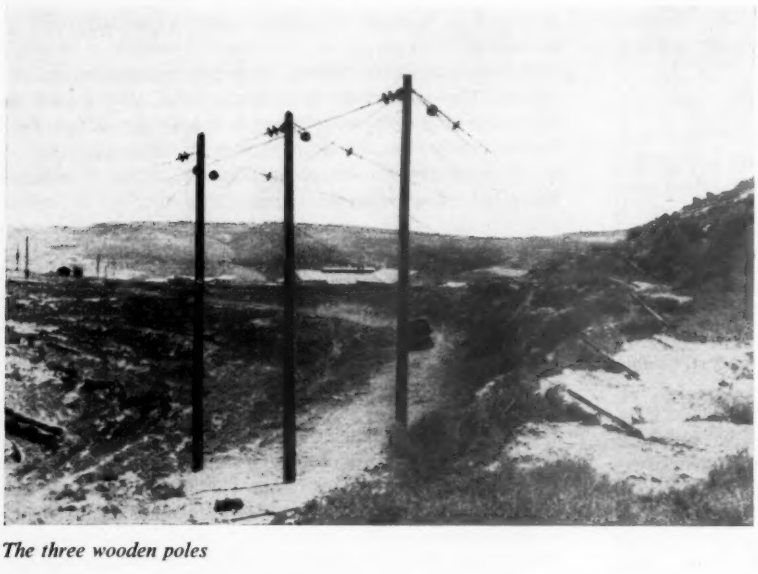
J. C. BRADBURY-WILLIAMS, ASSOCIATE

44 Birdwood Road
24th November 1960 Maidenhead, Berkshire

## *AN UNUSUAL ARRANGEMENT*

Dear Sir—The illustration below shows an unusual erection of h.v. overhead lines.

A 22kV line in the Jerusalem district (0·16in$^2$ steel-cored aluminium conductor) crosses a valley in a span of 2063ft in the north–south direction and continues at an angle of 90° in the west–east direction with a span of 725ft.



*The three wooden poles*

In order to ensure an adequate spacing between the conductors, three wooden poles were erected at the point of the angle, and each conductor was strung in both directions on a separate pole. The poles were anchored in both directions by line-stays. The arrangement proved very efficient and was cheaper than a lattice pole with cross-arms.—Yours faithfully,

J. GOLDHAMMER, ASSOCIATE MEMBER

Planning Engineer, Jerusalem Electric Corporation
12 Shikun Kiriat Moshe
11th November 1960 Jerusalem, Israel

## *13AMP FUSES*

Dear Sir—I have been disturbed by the number of people who, although having a 13amp ring main in their house, connect up every apparatus with a 13amp fuse, solely because it is supplied with the new plug by the manufacturer.

Surely a more suitable scheme would be to supply the plugs unfused so that the retailer could ask what fuse was required before sale.—Yours faithfully,

2/Lt. N. BULLEN, GRADUATE

6 (Veh.) Trg. Bn. R.E.M.E.
14th November 1960 Bordon, Hants

[The Chairman of the Wiring Regulations Committee, Mr. Forbes Jackson, writes: The Institution's Wiring Regulations require that, where plugs to B.S. 1363 are used, fuses of the appropriate rating shall be inserted in the plugs. It is recognized, however, that this is not always done, and the Wiring Regulations Committee share Mr. Bullen's concern. The question has had the attention of the Committee, who have received the suggestion he has made, on previous occasions.

Inspectors of the National Inspecting Council for Electrical Installation Contracting customarily check the type and rating of fuses fitted in 13amp plugs and, where these are incorrect, advise the consumer to have a fuse of the correct type and rating fitted.

It is perhaps a reassuring circumstance that, because of the superior performance of cartridge fuses to B.S. 1362 as compared with semi-enclosed (rewirable) fuses to B.S. 88 or 3062, and the fact that the fuses in 13amp plugs are not relied on to protect the fixed wiring of the installation, overfusing of such plugs is less potentially harmful than some of the overfusing which can occur with older arrangements of subcircuits. The introduction of the 13amp fused plug, even when its margin of discrimination is not exploited to the full, can therefore be regarded as an improvement in the safeguards against overfusing.

Mr. Bullen's suggestion, that to offer the plugs for sale unfused would be more suitable, does not offer a complete solution, because the use of a fuse of the correct type, i.e. to B.S. 1362, is more important than the choice of the correct rating, and unfortunately other types are available which will fit the fuse clips of a 13amp plug but are of inadequate breaking capacity.]

## *A GRAPHICAL SOLUTION OF THE KELVIN EQUATION*

Dear Sir—I suggest that the graphical method described by Dr. E. W. Marchant[1] for determining the current in a circuit containing capacitance, inductance and resistance may be extended to the general case where an applied voltage is included in the circuit.

Consider the differential equation:

$$L\frac{di}{dt} + Ri + \frac{q}{C} = E$$

where $E$ is the applied voltage.

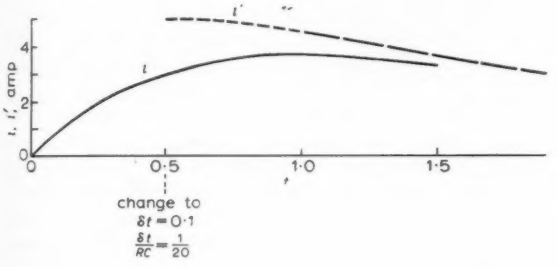
Thus $$L\frac{di}{dt} + Ri = E \pm \frac{Q_0}{C} - \frac{\int_0^t i\,dt}{C}$$

Let $E_0 = E \pm V_0$, $V_0 = Q_0/C$ and $I_0 = E_0/R$. The sign of $Q_0$ depends on the polarity of the initial charge with respect to the initial applied voltage. It follows that $di/dt = (i' - i)/\tau$ and $di'/dt = -i/CR$, as in reference 1.

In practice, for a steady direct applied voltage $E$, the graphical method will be exactly as described by Dr. Marchant, with the exception that:

$$I_0 = (E \pm V_0)/R$$

If the example in Fig. 3, reference 1, is considered [reproduced here as Fig. 1], in which $V_0 = 10$ volts, there is no external




1

e.m.f. ($E = 0$) and the circuit constants are $R = 2$ ohms, $C = 1$ farad, and $L = 1$ henry, the curves will be identical if the capacitor is initially uncharged and the applied voltage is 10 volts d.c. ($E_0 = E = 10$ volts; $Q_0$ and $V_0 = 0$). A similar result is obtained if $V_0$ is initially 10 volts and the applied voltage $E$ is 20 volts, so that $E_0 = E - V_0$. Again, if $E_0 = E + V_0 = 10$ volts, then $E$ could be 6 volts and $V_0$ an initial charge of 4 volts (in the reverse direction to the final charge due to $E$). In each case $E_0/R = I_0$ is 5amp, but the derivation of the capacitor voltage from the curve requires careful consideration.

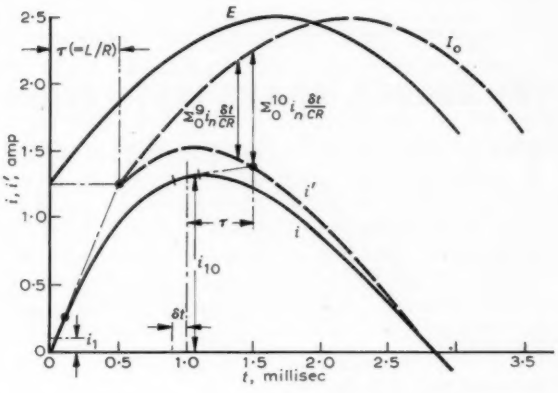
The foregoing may be self-evident, but now consider the case where the applied voltage is not constant.

It is not generally realized that the simple $LR$ circuit solved graphically in reference 2 for a constant voltage can also be solved in a similar manner if the applied voltage is a variable, provided that the variation with time is known. A recent article[3] gives examples which are of assistance when considering the present problem.

In the graphical method for the $LCR$ circuit there are two reference lines, $i = 0$ and $I_0$. Suppose $E = E_m \sin \omega t$: then $I_0 = (E_m \sin \omega t \pm V_0)/R$ and, if $i = 0$ is taken as a fixed base-line, the $I_0$ reference will be raised or lowered sinusoidally.

In reference 1 it is shown that $i' = I_0 - i_1$ at $\tau + \delta t$; $I_0 - i_1 - i_2$ at $\tau + 2\delta t$; and thus at any instant $n\delta t$, $i'_n = I_0 - \sum_0^n i_n \delta t/CR$. If now $I_0$ is varying, $i'$ will still be found by subtraction; but as the value of $I_0$ from which $i_1$ is subtracted is at $\delta t$, that from which $i_1 + i_2$ is subtracted is at $2\delta t$, etc., it facilitates construction if a second curve of $I_0$ is drawn, displaced by time $\tau$ from the applied wave $E$. The curve of $i'$ may be rising if $I_0$ increases at a sufficient rate.

If a sinusoidal voltage $E$ of 250 volts peak and 100c/s frequency is applied to a circuit at the instant when its value is half-peak, the construction will be as shown in Fig. 2. The




2

circuit constants are $R = 100$ ohms, $C = 10\mu$F, $L = 0{\cdot}05$H, the capacitor being initially uncharged. Peak $I_0 = E_m/R = 2{\cdot}5$amp, $\tau = L/R = 0{\cdot}0005$sec and $CR = 2\tau = 0{\cdot}001$sec. Let $\delta t = \tau/5$, thus $\delta t/CR = 1/10$. The initial slope, to give $i_1$, is $I_0/\tau$, as $i_n = 0$ at $n = 0$ in this case. Other points are found at each interval $\delta$t, e.g.:

$$i'_9 = I_0 \text{ (at } t = \tau + 9\,\delta t) - \sum_0^8 i_n \delta t/CR - i_9 \delta t/CR$$

to give $i_{10}$ on the tangent from $i_9$ to $i'_9$, between 9 and $10\,\delta t$. Similarly, $i_{11}$, for which the tangent is shown, and so on.

Another interesting point is the importance of the ratio $L/R$ and of $CR$. A graph drawn for one set of values can be converted to other time scales if these ratios are constant. Fig. 1 is equally applicable to a circuit of $R = 10$ ohms, $L = 0{\cdot}005$H, $C = 200\mu$F and $V_0 = 50$ volts with a current maximum at 0·001sec. Similarly, it may be convenient to express the time-constants as fractions of $2\pi$ on a sinusoidal supply.

The method can be usefully employed where mathematical solutions are difficult[4], and it is also possible to introduce other limiting conditions, e.g. a rectifier circuit[3].

We should be grateful to Dr. E. W. Marchant for introducing such an interesting method of analysis.—Yours faithfully,

C. F. AMOR, GRADUATE
22 The Tanis, Consciences Lane
Rowde, Devizes,
23rd November 1960 Wiltshire

1 MARCHANT, E. W.: *Journal I.E.E.*, September 1960, **6**, p. 536
2 BENSON, F. A., and HARRISON, D.: 'Electric-circuit theory' (Edward Arnold, 1959)

3 AMOR, C. F.: 'Graphical analysis applied to simple rectifier circuits', *I.E.E. Students' Quarterly Journal*, June 1960, **30**, p. 155
4 MARCHANT, E. W.: *Journal I.E.E.*, November 1960, **6**, p. 649

### *LETTERS FREE AND EASY*

Dear Sir—May I suggest the time is now appropriate to rename the *Journal* 'The Chartered Electrical Engineer'.

This will, I suggest, be more in line with the interests and standards of The Institution.—Yours truly,

C. C. BARNES, MEMBER
Mead Cottage
24 Mead Crescent
Sutton, Surrey

1st December 1960

---

## THE COUNCIL OF THE INSTITUTION: MEETING ON 1st DECEMBER 1960

THE following summary of reports received and decisions reached by the Council of The Institution at their meeting on the 1st December 1960 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meeting, as some items are to be the subject of further discussion by the Council.

### Subscriptions—'50 year' rule

The Council received a report from the Finance Committee, introduced by Mr. C. T. Melling, Chairman, relating to the rule providing for the remission of the subscriptions of members with 50 years' continuous membership. On the 1st January 1961 this will apply to 33 Members, 36 Associate Members and two Associates; of these, 54 members have already become life-members or retired non-paying members, and the remission of subscriptions under the rule will thus apply to the remaining 17 members.

### Membership

The Council gave final confirmation of the election of those candidates whose names had been published with the October 1960 *Journal*, to become effective from the 1st December 1960. Taking these into account, the total membership at that date was 47092.

### Institution Summer Meeting, 1962

On the recommendation of the General Purposes Committee, the Council were very pleased to accept the invitation of the Mersey and North Wales Centre for the Institution Summer Meeting in 1962 to be held in the area of the Centre, based on Liverpool.

### The Institute of Engineers, Pakistan

The Council received with pleasure an invitation from the Institute of Engineers, Pakistan, for The Institution to be represented at their seventh Annual General Meeting and Convention to be held in Dacca at the end of February and beginning of March 1961.

### Informal Meetings

The President welcomed Mr. G. Millington, Chairman of the Informal Meetings Committee, who was present by invitation, in the absence of the Chairman of the Papers Committee, to present proposals for the reorganization of the work of the Informal Meetings Committee. In discussing the proposals, the Council agreed to a change in the period of office of Specialized Section Committee representatives, but did not accept a suggestion that the title of Informal Meetings be changed, since it was felt that the term 'informal' was the most apt description of what the meetings were intended to be.

The Council also rejected a proposal to publish brief summaries of discussions at Informal Meetings in the *Journal*, omitting speakers' names and identifiable references, since it was felt that any step towards recording the proceedings would restrict the freedom traditionally enjoyed at these meetings.

### National Joint Committee on Materials Handling

The General Purposes Committee proposed that The Institution should withdraw from participation in the work of the National Joint Committee on Materials Handling, since the interest its activities hold for The Institution is negligible. The Council are at present represented by an observer only. It was agreed that The Institution should no longer participate in the committee's work.

### Professional Engineers' Association of Cyprus

The Council noted with interest the establishment of the Professional Engineers' Association of Cyprus and directed that a letter conveying their good wishes be sent to the association.

### Sir Willis Jackson's visit to Mexico

Sir Willis Jackson gave the Council an interesting account of his recent journey to Mexico, where he had visited the University of Mexico and the Polytechnic. Sir Willis referred to the need for British interests to be more fully represented in the large number of oversea fellowships etc. offered to Mexican nationals by foreign countries.

### Dr. G. A. V. Sowter's visit to Hong Kong

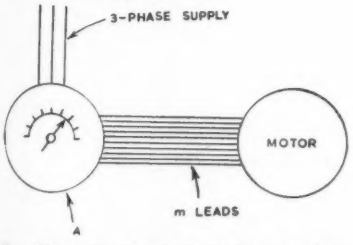
Dr. G. A. V. Sowter reported that he had had an opportunity during a recent visit to Hong Kong of conveying the good wishes of the Council to their Oversea Representative for the Far East and to the Chairman and Committee of the Hong Kong Joint Group.

# Brushless variable-speed induction motors

*A short article* based on two Utilization Section papers: paper 3149 entitled 'The logmotor—a cylindrical brushless variable-speed induction motor' by Prof. F. C. Williams, O.B.E., D.Sc., D.Phil., F.R.S., Member, E. R. Laithwaite, M.Sc., Ph.D., Associate Member, J. F. Eastham, M.Sc., and L. S. Piggott, M.Sc., Associate Member; and paper 3262 entitled 'Brushless variable-speed induction motors using phase-shift control' by Prof. Williams, Dr. Laithwaite, Mr. Eastham, and W. Farrer, M.Sc., Graduate. The papers were published individually in February and May 1960 respectively and will be republished in Part A of the Proceedings. They were read at Savoy Place on the 10th November 1960 before the Utilization Section (see p. 56). The authors are in the Electrical Engineering Department, University of Manchester.*

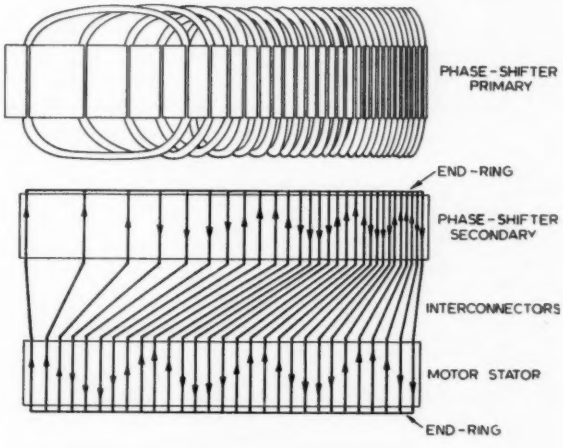
In a normal induction motor, stator windings which are uniformly distributed over a slotted, laminated core generate a magnetic field which rotates in the air-gap at synchronous speed. The number of stator slots and the number of poles determine the average phase difference between currents in adjacent slots. For example, in an 8-pole machine with 48 slots having a double-layer $\frac{5}{6}$-chorded winding, the stator-current phase progresses by 30° per slot. To halve the synchronous speed, it is necessary to double the number of poles. In terms of phase change, the stator winding must be rearranged to give a stator-current phase progression of 60° per slot, equivalent to compressing one pole into three slots.

This concept of stretching or compressing the number of slots per pole by changing the phase increment per slot is the basis of the design of two new types of brushless variable-speed induction motor.




1 *Generalized pole-stretching machine*

Both machines use a pole-stretching technique which involves supplying at least a part of the stator winding from a phase-controlling regulator or regulators. Both machines may be represented diagrammatically by the arrangement shown in Fig. 1. Machine A is a device which takes in power from a 3-phase supply and redistributes it into *m* leads which feed the motor. The arrangements within the machine A and the motor are such that, when the position of the control handle on A is changed, all the pole-pitches of the stator-current distribution on the motor are changed by the same amount, yielding a uniform-velocity field of a different value.




2 *Arrangement of windings in a logmotor*

## The logmotor

In the logmotor, the polyphase primary winding of the phase-shifter is so arranged that successive pole-pitches around the periphery constitute a logarithmic sequence. An arrangement of these primary coils is shown in Fig. 2. In this diagram, the slots are also logarithmically spaced, although this is not a necessary feature of the construction, and winding systems in uniform slotting have been developed. These are clearly the only windings which will be used in practice; the arrangement shown in Fig. 2, however, gives a better picture of the principle of operation.

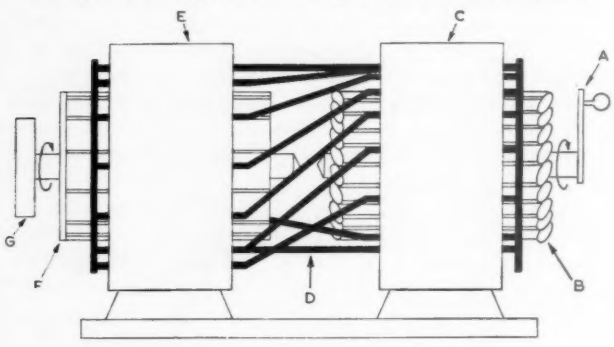
The secondary winding of the phase-shifter consists of single conductors in slots, all connected to a common ring at one end. Again, logarithmic slotting is shown for simplicity. The free ends of the conductors are connected to free ends of a set of conductors in the slots of the motor stator, the other ends of which are connected to a common ring.

Examination of Fig. 2 shows that successive pole-pitches of the current wave, which in the phase-shifter secondary are logarithmically related, are so routed by the interconnectors as to yield a uniformly distributed pole system on the motor stator. The primary and secondary of the phase-shifter may

* This article and those following are based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics, and the content of the articles is not necessarily confined to the subject-matter of the original papers

now be regarded as the C and D scales of a slide-rule, so that movement of the one relative to the other produces a different pole-pitch on the motor stator, thereby changing the speed of the field.

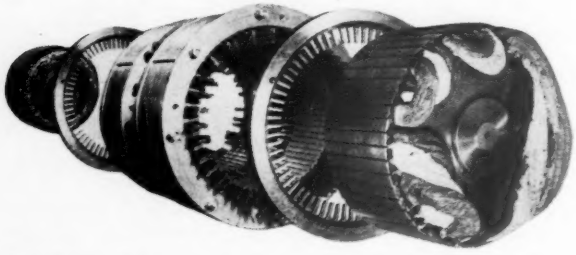
A schematic lay-out of a logmotor is shown in Fig. 3 and an exploded view of an experimental model in Fig. 4. Speed control over a range of 4 : 1 was possible with this machine.




**3** *Construction of transformer and motor as a unit*

A speed-adjusting handle
B transformer primary
C transformer secondary
D interconnectors
E motor stator
F squirrel-cage rotor
G output shaft

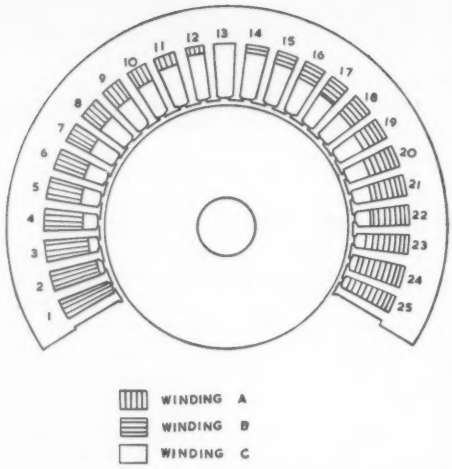
**4** *Exploded view of experimental model of logmotor*



## The phase-mixer

Fig. 5 shows a section through the winding of the motor stator of a phase-mixer motor. Each of the three windings occupying the respective areas shown is conventional, except that the number of turns in successive coils is reduced as required by the reduced space available. All three windings have the same pole-pitch. If all three were connected in series and fed from a 3-phase supply, the stator winding would be identical with that of a section of a conventional induction motor. However, windings A and B are fed from the secondaries of two conventional phase-shifters whose primaries are both in series with winding C.

The vector diagrams of the currents in some of the slots are shown in Fig. 6 for phase-shifts of zero and 45°. The phase-shifters used to feed windings A and B have a common shaft and are connected with opposite phase sequence, so that, when winding A is shifted in phase by $\theta°$, winding B is shifted by $-\theta°$. The maximum phase-shift permissible is

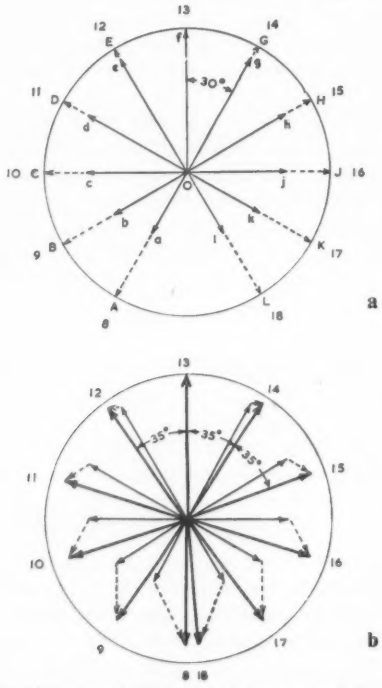



**5** *Arrangement of stator windings in a pole-stretching motor*

limited economically to perhaps ±120°. Short-stator effects place a limit on the minimum number of poles on the stator, so that the speed range is limited to about 2 : 1. Extension of the range is possible using more phase-shifters.

The logmotor can be made to operate as a constant-torque machine or with torque increasing with speed, whereas the phase-mixer is better suited to constant-power applications.

621.313.333.2 : 621.316.718.5
621.313.333 : 621.316.718.5




**6** *Vector diagrams for effective current per stator slot*
a $\theta = 0$ b $\theta = 45°$

# Radiocommunication in the power industry

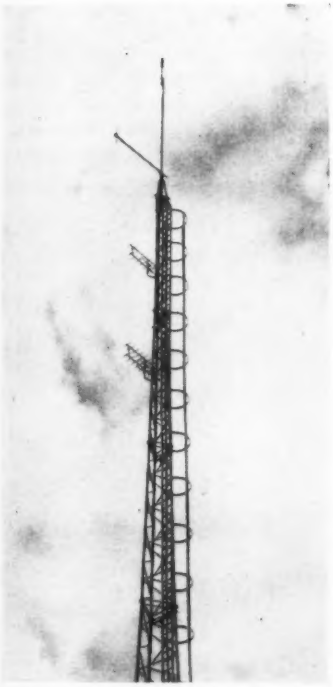
*A Supply Section paper (3290) of the 'integrating' type, with the above title, by E. H. Cox, Member, and R. E. Martin, D.F.H., Member, was read before the Supply Section on the 16th November 1960 at Savoy Place (see p. 57). This brief account is based on the paper, which was published individually in July 1960 and will be republished in Part A of the Proceedings.* *Mr. Cox is with the Midlands Electricity Board, and Mr. Martin is at the Central Electricity Research Laboratories.*

THE many aspects of the operation of any large production and distribution industry require a variety of telecommunication facilities. The electricity supply industry by its very nature needs comprehensive telecommunications, and the provision of the requisite remote-control, telemetering and allied equipment has engaged the attention of specialists for many years.

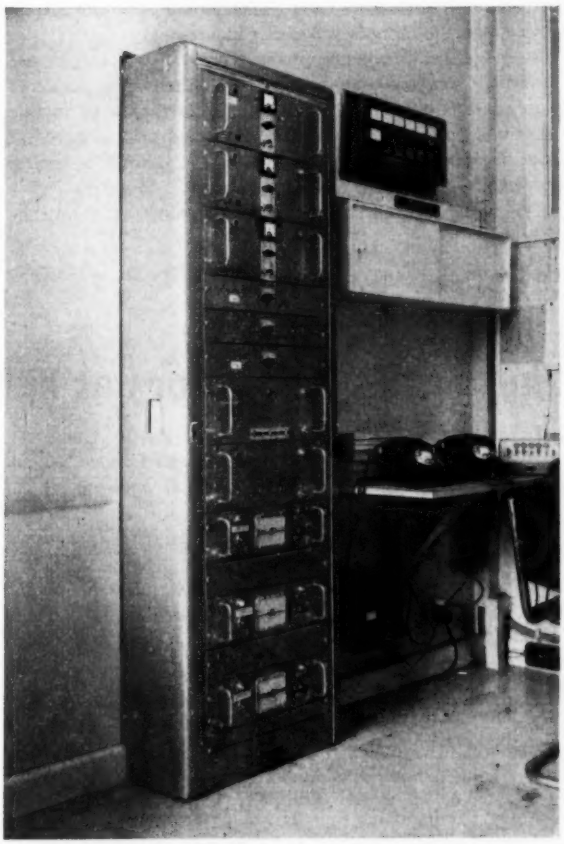
## 'Teleoperations'

Voice telecommunication is only a small part of the work of such engineers, who have the task of bridging the gap between the heavy-current high-voltage engineers on the one hand and the electronics engineers on the other. The problems arising from the growing utilization of electronic and telecommunication techniques by power engineers require a knowledge of both fields in applying the art of *Fernwirktechnik*.

There is no direct translation of this term, which groups together all those forms of communication employed by the electricity industry, such as remote control, telemetering, and protection, but specifically excludes man-to-man communication such as by telephone. The nearest English equivalent is perhaps 'teleoperations'.



1 *Mast of Electricity Board v.h.f. mobile-radio base station*



2 *Electricity Board unattended v.h.f.-radio base station*

In the past and also, to a large extent, at present, the channel of communication for these 'teleoperation' services has been private or rented cable circuits. Power-line carrier is also employed to some extent, and, with improvements in the techniques which are constantly being made, its use is likely to grow.

## Mobile radiocommunication

Radiocommunication is being employed to an increasing extent for man-to-man telephonic communication, particularly where mobile service is required. Fig. 1 shows the

mast of a v.h.f. mobile-radio-scheme base station. Radio-communication is also being used to an increasing extent by power engineers for 'teleoperations' where, by reason of flexibility, reliability or economics, advantages exist over other methods.

Mobile radiotelephony is now widely used in the electricity supply industry, particularly for the co-ordination of engineering work on the transmission and distribution networks. It is also used to an increasing extent for commercial consumer-service communication. Over 3200 mobile stations are in service, and the number is steadily increasing.

Many of the problems arising from the widespread use of mobile services have been solved, often as a result of experience. It is likely that the increase in the use of mobile radio will continue as new uses are found and as coverage from fixed stations is improved. Fig. 2 shows a typical unattended v.h.f.-radio base station.

The need for careful forward planning of frequency allocations in relation to the organization of the whole industry and its geographic and administrative boundaries is emphasized in the paper. Close co-operation with the gas and coal industries has enabled specific frequency requirements to be forecast and has assisted in enabling sharing of frequencies and in the reduction of mutual interference. These industries have also been active in stimulating the development by industry of special equipment for remote indication and control, using the latest electronic techniques and suitable for use over either line wires or radio circuits.

Fixed-to-fixed v.h.f. radio has not been employed to a great extent, owing to the necessity for conservation of frequencies for mobile working. However, the development of economic flexible microwave systems specifically engineered for power-system application, and the possible requirement for telemetering and protection systems utilizing high-speed digital data transmission, will change the picture.

621.396.931 : 621.311.1

# Phase control of rotors at high spinning speeds

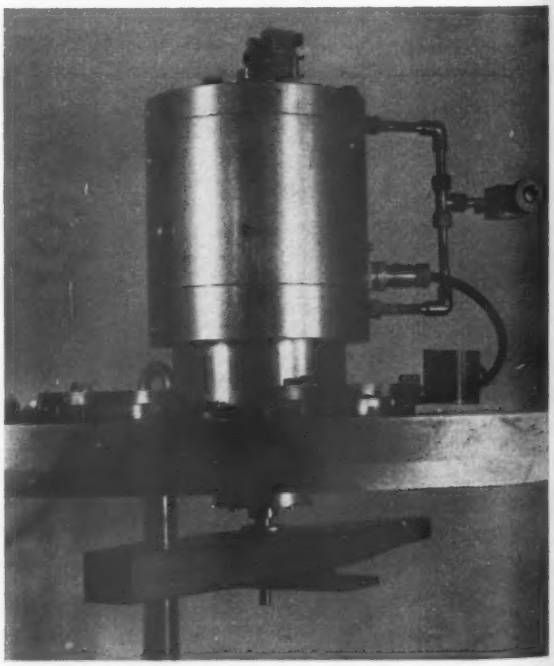
*A short article based on a Measurement and Control Section paper (3336) with the above title by P. A. Egelstaff, B.Sc., Ph.D., H. J. Hay, M.Sc., Ph.D., G. Holt, J. F. Raffle, M.Sc., Ph.D., and J. R. Pickles, A.M.I.Mech.E. The paper is published this month in Part B of the Proceedings. Messrs. Egelstaff, Hay and Holt are, and Mr. Raffle was formerly, at the U.K.A.E.A. Atomic Energy Research Establishment, Harwell. Mr. Raffle is now with the Cementation Co., and Mr. Pickles is with the Rover Co. Ltd.*

A DRIVE unit (Fig. 1) has been designed to operate at high speeds with very low power losses, so that the angular position of a rotor can be controlled within close limits relative to other similar units or a standard. The principal features of the unit (Fig. 2) are a hysteresis motor, air-lubricated journal bearings, and a magnetic thrust bearing, so that there are no friction contacts on moving parts. The useful speed range extends from 3000 to 60000 r.p.m., and the power loss rises to about 10 watts at the higher speed.

This equipment was developed to drive neutron choppers for time-of-flight spectrometers. Combinations of four units which are working on the Dido reactor at Harwell and on the N.R.U. reactor at Chalk River, Canada, require the relative phases of the rotors to be maintained within 0·1° or 1° for many days at speeds between 5000 and 50000 r.p.m. Single units have also found applications in work where the extremely small power loss or the low vibration level is a necessity.

## Hysteresis motors

Hysteresis motors have been selected as the prime movers because they have the advantage of being self-starting and synchronous and hence several units will have the same average speed without any elaborate servo controls. The rotor of this type of motor is a shell of magnetically hard material on which magnetic poles are printed by the rotating field from the stator. Since the final position of the poles is not determined until the rotor drops into synchronism, it is necessary



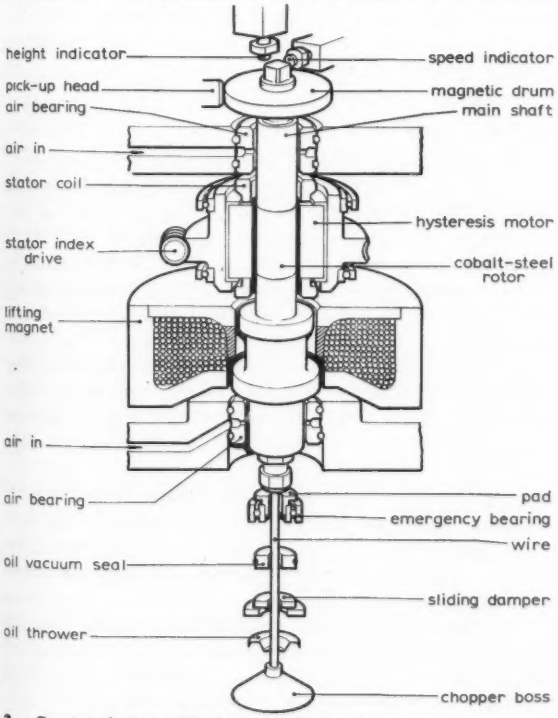
1 *High-speed drive unit*

to provide means for turning the stator to bring different units into the desired phase settings.

Small fluctuations in the load or power supply can set up oscillations of the rotating system about the driving field, but these can be fairly easily damped by electronic methods to less than 0·05°. A common power supply keeps the long-term drifts between units to a similar size, and adjustments to the stator position can be made manually each day or two.

### Magnetic bearing

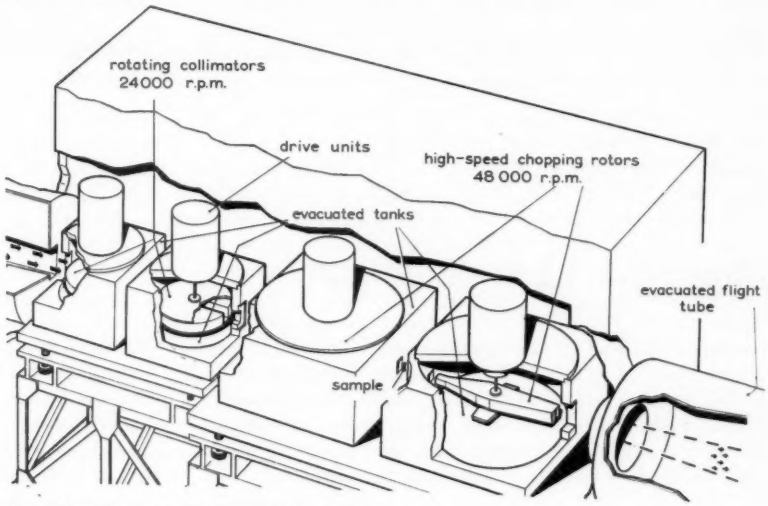
Since the neutron choppers may have peculiar shapes which are difficult to balance dynamically, they are suspended from the driving shaft on a flexible wire and spin in a vacuum tank to eliminate windage losses. Their weight may be up to 20lb and is taken by a two-gap axial-plunger magnetic bearing. Such a bearing is unusual because it is unstable against sideways movement of the plunger, but a suitable choice of the air-gap dimensions allows the sideways forces to be kept well below the load limits of the air bearings, which have only 0·001 in. radial clearance. The plunger has a stable vertical position, and can be made of a diameter small enough for the material not to distort at the highest operational speed.




2 *Sectional view of high-speed drive unit*

### Neutron spectrometer

The basic idea of a time-of-flight spectrometer is to modulate a continuous beam of neutrons from a reactor by a rotating shutter (the chopper), and then to time the neutrons over a measured distance; the distribution in arrival times gives the velocity spectrum of the neutrons in the beam. This type of equipment is widely used for neutron-physics experiments.




3 *Phased-rotor neutron spectrometer*

The detailed design of the chopper depends on the particular range of neutron energies and the materials which are used, but a typical chopper consists of a disc of material having high neutron-stopping power to provide adequate shielding in the 'off' position, with a diametral slot whose shape determines the range of velocities and mean velocity of the neutrons transmitted in the 'on' position. The time duration of the neutron burst depends on the peripheral speed of the chopper.

The range of usefulness of a spectrometer can be increased if it is possible to separate the various functions of the chopper into different rotors; this also increases the safety, since each rotor may be made smaller and will have much less stored energy to release in the event of an accident. For example, two simple choppers in series with adjustable separation and phase difference are equivalent to one large rotor with variable diameter and slot curvature, so they can be used as a neutron filter with a pass-band of separately variable width and centre. To keep the position of the pass-band steady, it is usually necessary to maintain the relative phase of the choppers to within about 0·1°.

More rotors can be added to provide extra neutron shielding when the chopping slits are off the beam line, i.e. to improve the signal/noise ratio, and if they rotate at a submultiple of the chopper speed they can control the burst repetition rate.

These rotors usually have rather wide slots, so need only be phased within 1° or 2°.

### Dido reactor

The spectrometer currently installed on the Dido reactor (Fig. 3) uses resonance-energy neutrons whose flight times range from a few milliseconds to a few microseconds over a 100m path. Operation has started with a pair of 10in.-radius chopping rotors at 12000r.p.m., giving a 2microsec neutron burst, and a pair of 10in.-diameter rotors at 6000r.p.m. for extra shielding. The rotors are made of glass fibre, and the speeds will be raised as experience is gained with the properties of this material—its potential strength is such that 48000r.p.m. should be possible for the fast pair of rotors.

Many hours of operation have established the reliability of the drive unit.

Wear on the bearings is almost negligible, and the phase stability can apparently be maintained indefinitely, for these instruments have been run continuously for periods of up to 1000 hours.

621.313.334 : 539.12

# Improved I.L.S. localizer

*A brief article based on an Electronics and Communications Section paper (3357) entitled 'The problem of improving the British Instrument Landing System localizer for automatic landing' by A. N. Beresford, B.Sc., and J. D. Asteraki, M.A. The paper is published this month in Part B of the Proceedings. The authors are at the Royal Aircraft Establishment.*

WHEN landing an aircraft, the pilot endeavours to touch down within about 10ft of the runway centre-line. In the British automatic-landing system, this final manoeuvre is accomplished by using the guidance provided by a pair of cables carrying alternating current which extend from the touch-down point about a mile into the undershoot area.

### Critical stage

There are four reasons why an I.L.S. localizer built to the existing I.C.A.O. specification is not suitable for use at this critical stage. They are:

(i) that the radio course-line may wander up to ±20 minutes of arc from the extended runway centre-line. This is equivalent to a lateral displacement of 50ft at touch-down
(ii) that existing airborne receivers do not have the required stability, and the scatter on output error voltage for a given displacement is large
(iii) that, although a standby transmitter is provided, the existing equipment does not provide continuous operation in the event of first transmitter failure. A period of 7sec elapses before the standby transmitter is brought into operation
(iv) that the signal/noise ratio on the approach path is extremely low.

The first three points are equipment-engineering problems and can presumably be solved if sufficient time and money are spent on them. The fourth point is more difficult.

### Course errors

The term noise includes those signals which originate from the localizer but which, after reflection from objects in the field of view, give false information. The majority of these objects stand on the ground and are thus in a lower field-strength region than a landing aircraft. Although they cause bends in the beam, these are relatively small and are more or less permanent.

However, other aircraft in the vicinity are in a much higher field strength and can cause very troublesome interference. Course errors, as much as 1°, can be caused by aircraft flying across the airfield at 10000ft.

This is, perhaps, not very surprising, because with existing localizers only about ½% of the radiated power goes directly into the funnel (about 5° in elevation and ±10° in azimuth) used by landing aircraft. The solution to the problem is to construct an aerial system which puts nearly all the energy where it is required.

### Aerial design

The design of the aerial is not completely straightforward, since, in general, structures much over 12ft high cannot be tolerated because of the hazard to low-flying aircraft. As the wavelength is 9ft, directivity can be achieved only by a Yagi-type array. With this type of array, it is difficult to shape independently the horizontal and vertical plane patterns. Work is proceeding on the problem, and the future role of I.L.S. will largely depend on the results.

A solution to the radiation-pattern problem which comes to mind is to alter the frequency to the microwave band. A height of 12ft would be more than adequate for the required directivity. However, this will introduce other problems.

First, the aircraft aerial should have reasonable cover in all directions and in particular should have uniform cover over ±30° in azimuth and from +5° to −10° in elevation about the aircraft datum line. This becomes more difficult as the frequency increases.

Secondly, while runways are fairly close together, the airborne receiver must have high selectivity so that only the signal from the appropriate localizer is received. It is a moot point whether this is easier at microwave frequencies or not.

Although there have been many attempts to produce a

microwave system, none of them has had the same success as the existing system. It would therefore be unwise to abandon the existing system before every avenue for improving it had been explored. 621.396.933.23

# TRAINING OF OVERSEA GRADUATE ENGINEERS

*A short article based on a paper (3358) entitled 'The training of oversea graduate engineers, with particular reference to the F.B.I. scholarships scheme' by W. Abbott, C.M.G., O.B.E., Ph.D., B.Sc., M.I.Mech.E. The paper was read on the 3rd November 1960 at Savoy Place before a Joint Meeting of The Institutions of Civil, Mechanical and Electrical Engineers. A report of this meeting appears on p. 58. The author is Director of Studies, Federation of British Industries.*

In the paper, the author deals in general with the training of the graduate engineer from developing countries oversea, but makes particular reference to the scheme operated in the long-term interests of trade by the Federation of British Industries. The scholars dealt with in this scheme are of two types: young men who have recently graduated and who come for two years, and mature engineers who have had at least five years' industrial experience and who come for periods of from four to 12 months.

The F.B.I. scheme is not a large one, but its scholars come from a wide range of countries, enumerated below, and are carefully selected in those countries by committees on which British representatives serve:

Argentina, Australia, Bolivia, Brazil, Ceylon, Chile, Colombia, Cuba, Ecuador, Finland, Guatemala, Honduras, Hong Kong, India, Iran, Iraq, Jordan, Kenya, Kuwait, Lebanon, Malaya, Mexico, New Zealand, Nicaragua, Nigeria, Panama, Pakistan, Peru, Philippines, Portugal, Rhodesia, El Salvador, South Africa, Spain, Sudan, Thailand, Turkey, Uruguay and the West Indies.

It can be safely assumed that the F.B.I. scholars will be future leaders in the engineering field in their own countries.

Canada is separately covered by the Athlone Fellowship scheme.

Some of the countries mentioned have reached a more advanced stage of development than others. Because of this, training requirements cannot be standard, and each case ought to be examined on its merits.

### Postgraduate training in Britain

As it is apparent that, for the sake of our industrial prosperity, Britain will have to accept more and more men from oversea countries for industrial training and experience, it is desirable to examine our training schemes and to determine whether in fact they are quite suitable for this purpose. Experience with the F.B.I. scheme (and the Athlone Fellowship scheme) indicates that some of our training arrangements are in one way or another inappropriate; and in the paper the author points out these defects and discusses remedies.

Industrial training schemes for British graduates in the United Kingdom are naturally framed to meet the recommendations of the major professional engineering institutions. These permit a considerable variation; but, nevertheless, as far as those of The Institutions of Mechanical and Electrical Engineers are concerned, the bulk of the industrial training schemes are devised on the assumption that the graduate is going to be a producer of engineering equipment. On this basis, he is rightly required to be very familiar with workshop processes and techniques: indeed, craft operations bulk largely in the training programmes.

The author discusses in the paper the British philosophy of postgraduate professional training and then compares the requirements of the three major engineering institutions, the Civils, the Mechanicals and the Electricals.

This comparison reveals a difference, in that The Institution of Civil Engineers uses an Index of engineers willing and able to provide training. These engineers, who are Corporate members of the I.C.E., accept the conditions laid down by that Institution and give training under a prescribed form of agreement; they also sponsor the young graduate's report which he presents at the professional interview, and they authenticate the work which he offers.

The young civil engineer from oversea is therefore in contact from the beginning with Chartered Civil Engineers with whom he can always discuss his problems. His treatment is more professional than that accorded graduates entering the other engineering branches.

### Requirements of the oversea engineer

The majority of young engineers from the developing countries oversea, particularly from the Latin American republics, are not usually interested in becoming members of British engineering institutions—language often being the main deterrent—and, while they fully appreciate the purpose of the schemes of training laid down by the Institutions, they feel that their own requirements are often not met by these schemes. Incidentally, they frequently state that the British graduate feels much the same, but goes through with the course uncomplainingly for the sake of the award.

The common complaint of the oversea man, particularly one from a very underdeveloped country, is that he will not be called on, in the foreseeable future, to produce heavy capital equipment—for example, generating plant. Rather will he purchase, install, operate and maintain. He is not really interested in becoming 'the complete engineer' in our understanding of the term. Again, he would prefer not to stay with one firm, however comprehensive its operations,

but to spend time with several and thus gain knowledge of a wider range of British manufactures.

Such an arrangement would be greatly in our trading interests, but short block periods of training are usually regarded with disfavour by most industrial firms. There are obviously very good commercial reasons for giving the foreign graduate a treatment different from that arranged for the British engineer, if it will ensure that he does get a survey of our industrial potential.

For the oversea civil engineer not interested in joining The Institution of Civil Engineers, there is something to be said for a mixed course, although this is objected to by members of the profession, who recommend that the youth should see a job through, if possible, from start to finish. A civil engineer from Australia, for example, wants to get in Britain what he cannot get at home: experience in prestressed concrete and in soil mechanics are common requirements. At the moment, the prescription is that the young engineer must accept the day-to-day work available in the office of a consultant or in the field with a contractor.

### Letter from Sir Claude Gibb

As far as industrial training is concerned, the late Sir Claude Gibb, when he was Chairman of the Athlone Fellowship Committee, addressed a letter to a number of leading industrialists which set out in very clear terms what the requirements of the alert graduate from a rapidly developing country really amount to. The letter is worth quoting in part, because it contains the germ of the author's paper:

'If then more Fellows are to be attracted to industrial experience as opposed to university work, we must ensure that the industrial training in the United Kingdom is really attractive to the young Canadian engineer, bearing in mind his background and his own knowledge of the needs and desires of Canadian industry. This frequently means that the Canadian engineering graduate is not at all impressed by the United Kingdom "graduate apprenticeship course" of two years, which in most cases has been organized by United Kingdom industry in consultation with the Professional Institutions concerned and is primarily designed to meet the detailed requirements of the Institutions for corporate membership.

'We find that the Canadian graduate is anxious to be given work involving some responsibility and use of what he has learnt in his undergraduate course. He is not concerned with acquiring a craft skill or even knowledge of an engineering craft, since the organization of the engineering, and particularly the light engineering industry in North America, does not expect this type of skill or knowledge from the professional engineer.

'A number of engineering firms in the United Kingdom have realized the rather special needs of these young men and have, in fact, provided exactly the type of experience which they desire. There is no doubt that the policy of these firms has been greatly appreciated and will in due course pay handsome dividends.'

If for Canada is read Australia, New Zealand, South Africa, and to some extent Brazil and Argentina, the statement expresses a widespread requirement.

This is not to say that the standard graduate-apprentice course is never popular. Many of the younger F.B.I. scholars, from countries as far apart as Iran and Mexico, have reported great satisfaction, because such practical training is quite unobtainable in their own countries. Moreover, it would be considered not quite proper for them so to work at home.

### Possible remedies

The developing countries oversea, particularly the emerging countries of the Commonwealth, are likely to turn to the United Kingdom for much more assistance in the technical training of their engineers, and the volume of the demand is likely to be very great. The author suggests that, if it is to be met satisfactorily, two actions are necessary: the acceptance by more and more firms of the responsibility of training oversea graduates; and a rethinking of the way in which these young men should be dealt with professionally. Other countries, industrial rivals, are paying great attention to this question of training, realizing the long-term commercial benefits which are likely to ensue. Great Britain cannot afford not to be in the forefront of these developments. 62:331.86

# HIGH-RESOLUTION RADIO TELESCOPE

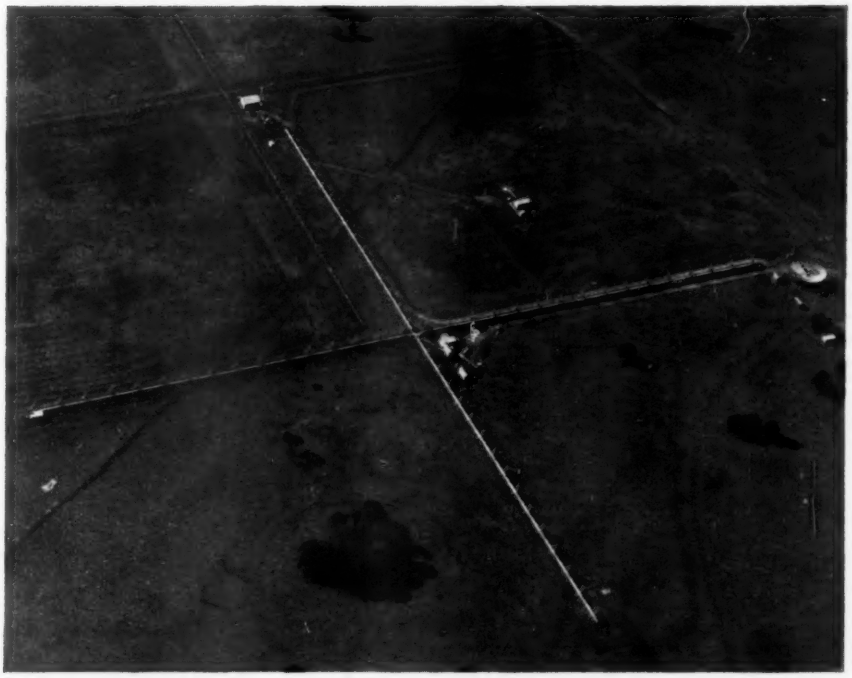
*A brief article based on an Electronics and Communication Section paper (3364) entitled 'The crossed-grating interferometer: a new high-resolution radio telescope' by W. N. Christiansen, D.Sc., N. R. Labrum, B.Sc., K. R. McAlister, and D. S. Mathewson, Ph.D. The paper is published this month in Part B of the Proceedings. Prof. Christiansen was formerly at the Commonwealth Scientific and Industrial Research Organization Radiophysics Laboratory, and is now Professor of Electrical Engineering at the University of Sydney, New South Wales, Australia. Mr. Labrum, Mr. McAlister and Dr. Mathewson are at the Commonwealth Scientific and Industrial Research Organization Radiophysics Laboratory, Sydney, New South Wales, Australia.*

Over most of the radio spectrum, radiation from the sun originates in the corona—the outer solar atmosphere—in regions which are difficult to observe by optical methods. Radio observations are therefore of great importance in the study of these exterior layers of the sun. In particular, much valuable information can be obtained from studies of the complicated distribution of radio brightness across the solar disc. Since the diameter of the sun is only about $\frac{1}{2}°$, such

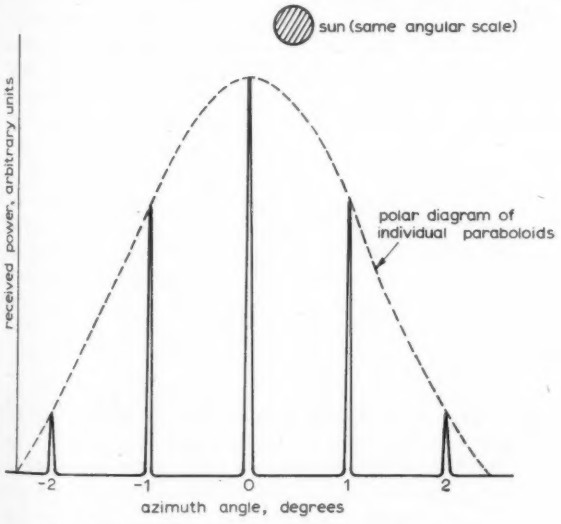
observations require angular resolution corresponding to an aerial beamwidth of a few minutes of arc.

This performance cannot readily be attained with conventional receiving aerials, and so investigations of solar brightness distribution have hitherto been made by various indirect methods. The instrument described here is the first decimetre-wavelength radio telescope with a pencil-beam response sufficiently narrow to provide, in a rapid and unambiguous fashion, the data for constructing detailed 'radio pictures' of the sun.

This device, which we have called the 'crossed-grating interferometer', is shown in Fig. 1. It has been in regular use since July 1957 for mapping solar radio isophotes at a wavelength of 21·2cm (another interferometer of the same type, operating at 9·1cm wavelength, has since been built at Stanford University, California).



1 *The crossed-grating interferometer at Fleurs, near Sydney, N.S.W.*



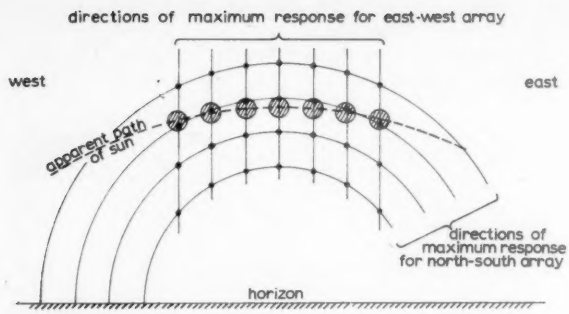

2 *Polar diagram of a single 32-element grating array*

### Principles of the new instrument

The aerial system combines the essential features of two earlier devices—the Mills cross and the multi-element or grating interferometer. It consists of two long arrays of uniformly spaced aerials, arranged in the form of a cross. An array of this kind is analogous to an optical diffraction grating; its polar diagram is a family of narrow fan-shaped beams (Fig. 2).

The beamwidth is determined by the length of the array, and the separation between adjacent beams by the spacing of the aerial elements. These dimensions have been chosen so that the fan beams are 2′ of arc wide and about 1° apart. Since this separation is twice the solar diameter, only one aerial beam can lie on the sun at any time, and the multiple response produces no ambiguities.

The arrays are connected to a common receiver through a phase switch, which reverses their relative phases at a low frequency. Signals which originate in areas common to both sets of fan beams are phase-coherent; they alternately add and cancel, giving an alternating component in the receiver output. This component is a measure of the radiation from the




**3** *Part of the multiple pencil-beam pattern, illustrating the method of scanning the sun*

The curvature of the fan-beams is somewhat exaggerated for the sake of clarity

regions, shown as small black circles in Fig. 3, where the two patterns intersect; the over-all response of the system thus corresponds to a multiplicity of very narrow pencil beams.

The instrument has, in fact, about the same angular resolution as a conventional paraboloid-reflector aerial with diameter equal to the length of either of the crossed arrays. The sensitivity of the interferometer is, of course, much lower than that of such a huge paraboloid; it is, however, fully adequate for solar observations.

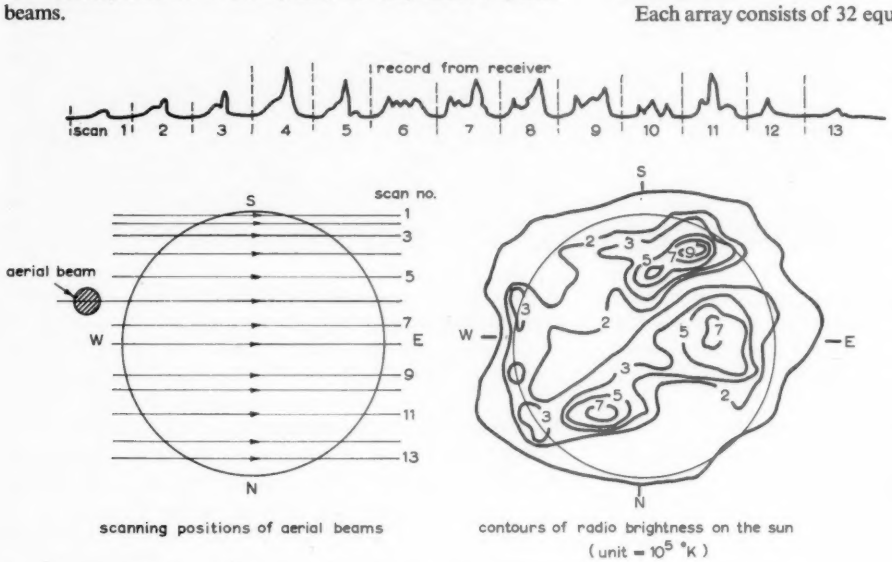
### Scanning the sun

Scanning from west to east across the sun is provided by the earth's rotation (Fig. 3). After a particular pencil beam has scanned a strip of the sun, the beam positions are moved about one beamwidth southwards, by means of phase-shifters in the north–south array, so that the next beam will scan an adjacent strip of the sun. In this way a complete radio picture of the sun is built up, television fashion, during an observing time of about an hour. This process is illustrated in Fig. 4. During the observations, the individual paraboloid elements are steered so that they are always pointed at the sun.

### Construction

Each array consists of 32 equatorially-mounted paraboloid-reflector aerials, 19ft in diameter, uniformly spaced along a 1200ft base-line. Open twin-wire feeders are used. An important feature is that all the aerials are connected to the receiver through equal lengths of transmission line; with this arrangement, thermal changes in feeder length produce no differential phase-shifts among the signal components.

The parts of this system are all relatively simple and cheap to build; the required high performance has been achieved by accurate positioning of the aerials and careful electrical adjustment of the completed arrays.




**4** *Stages in the production of a 'radio picture' of the sun*

621.396.677.3

# Railway-traction rectifier equipments

*A short review of a Graduate and Student Section paper entitled 'Fundamentals of a.c. railway-traction rectifier equipments' by K. Gunary. The paper was read before the South Midland Graduate and Student Section at Birmingham on the 9th December 1959 and was awarded a premium by the Council. The author is with the General Electric Co. Ltd.*

THE most desirable speed/torque relationship for a traction motor is that the motor should produce a high torque at low speeds while the load is being accelerated, and a reduced torque at high speeds sufficient to overcome the steady-state tractive resistance. The electric motor which has a characteristic most suited to these requirements is the one

in which the field and armature are connected in series. For the ideal unsaturated series motor, having negligible resistance, the torque is inversely proportional to the square of the speed for constant applied voltage; and the speed varies directly as the applied voltage and inversely as the current. Hence, one method of altering the motor speed, for a given tractive effort, is to vary the applied voltage.

### Economic transmission

A.C. series commutator motors have been developed for traction duty, but they suffer from commutation difficulties due to transformer e.m.f.'s induced in the armature coils. The most suitable traction motor is, therefore, the d.c. series motor, which, on all-electric equipments, has usually to be supplied with power from the overhead-conductor system.

In general, electric power is most economically transmitted at high voltages. The maximum practicable d.c. transmission voltage is approximately 3000 volts, the limitations being the restricted space available for the large diameter of the high-voltage traction motor and the difficulty in producing high-voltage direct current in the rectifier substation. If, therefore, advantage is to be taken of contact-wire voltages higher than 3000 volts, a.c. transmission is desirable, and the rolling-stock will have to carry a step-down transformer, on-load tap-changer, and rectifiers. This combination is, in fact, the salient feature of railway-traction rectifier equipments.

### Power equipment

The choice of power equipment and the design of the power circuit present a complex problem. The difficulty is to match the characteristics of the various items of equipment to produce a unit of maximum performance and reliability, within the permitted weight and space and requiring the minimum of maintenance.

When starting an electric locomotive, it is necessary to limit the motor current. For a d.c. locomotive this is achieved by placing a starting resistance and all the individual traction motors in series. On an a.c. locomotive the motors are permanently connected in parallel (or parallel sets of two motors in series), and the starting current is limited by applying to the motors, through the rectifiers, a low voltage obtained from the lowest tap on the transformer.

It follows, therefore, that the a.c. locomotive will have a greater starting adhesion than its d.c. counterpart of the same weight; or, for a given load, the a.c. locomotive need not be so heavy, and hence need not have so many axles as its d.c. equivalent. Consequently, to produce the smallest, and therefore cheapest, possible a.c. locomotive, it is essential to build a unit which weighs considerably less than the conventional d.c. locomotive and yet contains the convertor equipment, which, for the d.c. system, is housed in substations at the side of the track.

### Rectifiers

Pumpless mercury-arc rectifiers, developed for mounting on traction equipment, are of the single-anode type and fall into two classes—ignitrons, in which the cathode spot is initiated once every cycle, and excitrons, in which the cathode spot is present continuously. Fig. 1 shows an excitron rectifier. Each type has its advantages and disadvantages, and both are at present in service.

**1** | *Excitron rectifier*

The correct design of rectifier connections depends largely on the required direct voltage. The two principal rectifier arrangements are the bridge and the full-wave connections. Comparing the two circuits, the full-wave connection has the advantage of requiring a minimum of two rectifiers, instead of four as in the bridge connection. However, the full-wave-connected rectifiers have to be suitable for twice the peak inverse voltage.

From considerations of transformer size, the bridge connection is superior, since the whole of the secondary of the transformer carries current continuously; while, for the full-wave connection, each half of the secondary winding carries current for only half the time.

The traction-motor voltage is controlled by means of a transformer tap-changer; and, as there must be no loss in tractive effort during voltage-changing operations, on-load tap-changing schemes are used. All such schemes involve the insertion of an impedance into the circuit during the tap-changing sequence, the function of which is to prevent a momentary short-circuit between adjacent transformer taps.

### High- or low-voltage control?

Either h.v. or l.v. transformer tapping can be employed. With h.v. control the supply is fed to an auto-transformer from which tappings are taken to a fixed-ratio rectifier

transformer, while for l.v. control the supply feeds the primary of a rectifier transformer which has a tapped secondary.

The advantages of h.v. compared with l.v. control include: switching smaller currents; easier choice of step-voltages, owing to the large number of turns on the auto-transformer; and a greater inherent regulation on the l.v. taps because the number of turns on the rectifier transformer is not reduced.

However, l.v. control has the following advantages over h.v. control: lowest possible transformer size and lowest possible transformer losses, since the h.v. scheme requires the additional auto-transformer; and more-accessible tapping contacts, as they would probably be in air while the h.v. tap-changer contacts would be oil-immersed.

The single-phase full-wave rectification scheme used on rectifier equipments produces in the motor circuits a direct current with a predominant 100c/s harmonic ripple. This ripple current causes the motor field-flux to pulsate, giving rise to eddy-current and hysteresis losses in the iron, as well as transformer e.m.f.'s in the armature coils, and consequent commutator sparking.

To reduce the harmful effects of the ripple current, smoothing reactors are introduced into the motor circuits, and diverter resistors are placed in parallel with the motor field-windings. Compared with the field winding, the diverter resistor presents a low impedance to the ripple component of the current, and the amplitude of the flux pulsation is, therefore, reduced.

### Conclusions

Rectifier locomotives and motor-coach units are at present running successfully in a number of countries. A great deal of development remains to be done, and it is practically impossible to predict future trends.

No attempt has been made to suggest any ideal design, since it is considered that no one such design exists at the present time.

621.333 : 621.314.651.2

---

## *Synopses of papers*

THE following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. Reprints will be available about two months after publication

---

## Signal-generator calibration

*A synopsis of a Measurement and Control Section paper (3356) entitled 'The concept of equivalent source e.m.f. and equivalent available power in signal-generator calibration' by D. Woods, Associate Member. The paper is published this month in Part B of the Proceedings. The author is at the Ministry of Aviation.*

THE source impedance of a signal generator, for use in terminated conditions, has a direct effect on the accuracy of the load voltage. Signal-generator specifications rarely give detailed information about the variation of this parameter with frequency. Consequently, the user is generally forced to assume that it is constant and equal to the nominal value. The view is maintained that it is impracticable to apply corrections for this parameter, even if its value is known.

Three methods are analysed for calibrating the output level of signal generators, with a view to determining that method which minimizes the error in the load voltage due to source-impedance variation. The methods are each compared in terms of the voltage ratio produced across an arbitrary load impedance by an imperfect generator to a perfect generator. The voltage ratios are expressed in terms of the reflection coefficients of the generator and load impedances. The minimum and maximum of the ratios are given in terms of voltage standing-wave ratios. The results are equally applicable to coaxial and waveguide systems.

The recommended method employs the concept of equivalent source e.m.f. or equivalent available power. The requirements for a suitable instrument to measure these quantities are briefly discussed.

Recommendations are made regarding the manner of specifying the tolerances on signal-generator parameters which affect the accuracy of the load voltage, namely the calibration level, the attenuation and the source impedance.

621.317.312.029.6 : 621.373.42

## Analogue computer for coal-flow simulation

*A synopsis of a Measurement and Control Section paper (3324) entitled 'An electronic analogue computer for a coal transportation problem' by E. G. Anderson, B.Sc., A.Inst.P., Associate Member. The paper is published this month in Part B of the Proceedings. The author is with I.B.M. United Kingdom Ltd. and was formerly at the Central Electricity Research Laboratories.*

THE transportation problem and linear programming are defined, and an electronic analogue of the problem and its optimum solution is described.

A computer with a $5 \times 20$ matrix has been built using current and opposing e.m.f. to simulate coal flow and route costs respectively. The circuits are described, and a section on operating technique is included.

A typical problem and its solution are given, and it is concluded that a larger computer is feasible.

681.142 : 662.6.002.71

## Electrical analogue for heat waves

*A synopsis of a Measurement and Control Section paper (3337) entitled 'An electrical analogue for heat waves in an exothermic medium' by R. T. Ackroyd, M.Eng., Ph.D., Member, J. Houston, B.Eng., Graduate, J. W. Lynn, M.Sc., Ph.D., Associate Member, and E. Mann, B.Sc. The paper is published this month in Part B of the Proceedings. Dr. Ackroyd and Mr. Mann are with the U.K.A.E.A. Development and Engineering Group at Risley, and Dr. Lynn and Mr. Houston are in the Department of Electrical Engineering, University of Liverpool.*

THE authors describe the design, construction and operation of an electrical analogue used for simulating the conditions of propagation of heat waves in an exothermic medium.

The equipment is in two parts. The first is a passive *RC* network, which is the usual form of analogue for heat-conduction problems. The second consists of a function generator which calculates the stored energy released as the wave travels across the medium, together with the necessary switching apparatus. The function generator is switched rapidly along the path of the wave. Its output for any point is a function of the temperature at that point. As the wave reaches a given point, additional energy is released into the network. This modifies the conditions at each point to satisfy equations of the form:

$$-\nabla^2\phi + \rho\frac{\partial\phi}{\partial t} = f(\phi)$$

The authors also discuss the construction and operation of electronic switches capable of scanning the network and adjusting the conditions in times of the order of 5millisec per node. 621.317.79 : 681.142

## Tuning of e.h.t. transformers

*A synopsis of an Electronics and Communications Section paper (3368) entitled 'Third-harmonic tuning of e.h.t. transformers' by E. M. Cherry, M.Sc., Graduate. The paper will be published in Part B of the Proceedings. The author is in the Department of Electrical Engineering, University of Melbourne, Australia.*

A DETAILED analysis of third-harmonic tuning of e.h.t. transformers is given, using a simple, approximate equivalent circuit. It is shown that, if the leakage inductance is tuned to about the 2·8th harmonic of the flyback pulse by the stray capacitance,

(i) Ringing of the e.h.t. winding during the scan is eliminated
(ii) The e.h.t. voltage pulse is maximized, the increase being 55%
(iii) The voltage pulse applied to the driver tubes may be increased or decreased; the maximum reduction is 25%.

A theoretical transformer should therefore have a pulse step-up of 1·55/0·75, i.e. 2·07 times the turns ratio; practical transformers rarely give a step-up of more than 1·5 times the turns ratio. The explanation is in the approximate nature of the equivalent circuit used for the analysis.

The outline of an analysis using a complete equivalent circuit is given. 621.397.62: 621.314.222

## Transverse-film bolometer

*A synopsis of an Electronics and Communications Section paper (3392) entitled 'The design and performance of transverse-film bolometers in rectangular waveguides' by J. A. Lane, M.Sc., Associate Member, and D. M. Evans, Ph.D., B.Sc., A.Inst.P. The paper is published this month in Part B of the Proceedings. The authors are at the Radio Research Station, Department of Scientific and Industrial Research.*

EQUATIONS are derived which determine the design of film-type bolometers used for the measurement of microwave power. The results are discussed in relation to the concept of impedance in rectangular waveguides.

Measurements on an improved tunable-type instrument at a wavelength of 3cm indicate that power levels between 1 and 100mW can be measured in terms of a d.c. calibration with an error of not more than ±2%. 621.317.794 : 621.372.822

## R.F. interference in f.m. system

*A synopsis of an Electronics and Communications Section paper (3326) entitled 'Radio-frequency interference in multi-channel telephony f.m. radio systems' by R. Hamer, Ph.D., B.Sc., Associate Member. The paper is published this month in Part B of the Proceedings. The author is in the Research Branch of the Post Office Engineering Department.*

AN investigation is described of the effect of extraneous r.f. interference in f.m. multi-channel radiotelephony transmission systems. The noise power ratio in the output telephony baseband due to an r.f. interfering signal is derived theoretically, and comparison is made with measured values. When the practical limitations in the method of measurement are taken into account, it is concluded that the theoretical results are valid.

Results of general application in the design of radio systems are derived from the theory, and the analogy, in certain circumstances, with interference due to long-delay echo-signals is discussed. 621.391.82 : 621.396.65

## Coupled transmission lines as directional couplers

*A synopsis of an Electronics and Communications Section paper (3350) entitled 'Recent advances in the use of coupled transmission lines as directional couplers' by Ryutaro Koike, B.Sc. (Eng.), Graduate. The paper is published this month in Part B of the Proceedings. The author, who is with the Anritsu Electric Co. Ltd., Japan, is at present in the Department of Electrical Engineering, University College London.*

IF two similar coaxial transmission lines are coupled by sharing a common outer conductor for part of their length, so as to form a 3-conductor line, they constitute a symmetrical directional coupler.

In work on coaxial directional couplers at microwave frequencies up to 7Gc/s, new designs of coupled transmission lines have been developed for use as power monitors and variable attenuators. 621.372.832.43

## Contents of the current *Proceedings*

*The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in CAPITALS is the month in which a paper or monograph was published individually*

### PART A. POWER ENGINEERING (DECEMBER 1960)

*See the Journal for December 1960, p. 727*

### PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (JANUARY 1961)

SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C.*, LL.D., B.SC. **Inaugural Address as President** *January 1961*

T. B. D. TERRONI, B.SC. **Electronics and Communications Section: Chairman's Address** *January 1961*

**Centre, Sub-Centre and Group Chairmen's Addresses**

P. A. EGELSTAFF, B.SC., PH.D., H. J. HAY, M.SC., PH.D., G. HOLT, J. F. RAFFLE, M.SC., PH.D., *and* J. R. PICKLES. PAPER 3336M **Phase control of rotors at high spinning speeds** *January 1961*

R. T. ACKROYD, M.ENG., PH.D., J. HOUSTOUN, B.ENG., J. W. LYNN, M.SC., PH.D., *and* E. MANN, B.SC. PAPER 3337M **Electrical analogue for heat waves in an exothermic medium** *January 1961*

D. WOODS. PAPER 3356M **Concept of equivalent source e.m.f. and equivalent available power in signal-generator calibration** *January 1961*

E. G. ANDERSON, B.SC. PAPER 3324M **Electronic analogue computer for a coal transportation problem** *January 1961*

W. N. CHRISTIANSEN, D.SC., N. R. LABRUM, B.SC., K. R. McALISTER *and* D. S. MATHEWSON, PH.D. PAPER 3364E **The crossed-grating interferometer: a new high-resolution radio telescope** *January 1961*

A. N. BERESFORD, B.SC., *and* J. D. ASTERAKI, M.A. PAPER 3357E **The problem of improving the British Instrument Landing System localizer for automatic landing** *January 1961*

G. D. MONTEATH, B.SC., G. H. MILLARD, B.SC., *and* D. J. WHYTHE, B.SC.(ENG.). PAPER 3334E **Use of a high-gain television transmitting aerial in a populous area** *November 1960*

R. HAMER, B.SC., PH.D. PAPER 3326E **Radio-frequency interference in multi-channel telephony f.m. radio systems** *January 1961*

A. SANDOR, M.E.E., D.E.SC. PAPER 3333E **Emission from miniature hollow cathodes** *November 1960*

A. SANDOR, M.E.E., D.E.SC. PAPER 3363E **Pressed-oxide nickel-matrix cathode below apertured electrodes** *November 1960*

H. N. DAGLISH, B.SC., PH.D. PAPER 3344E **Electron emission from cold magnesium oxide** *November 1960*

D. J. MILLEN, B.SC., PH.D. PAPER 3331E **Microwave spectroscopy** *October 1960*

R. KOIKE, B.SC.(ENG.). PAPER 3350E **Recent advances in the use of coupled transmission lines as directional couplers** *January 1961*

G. O. CHALK, M.SC. PAPER 3342E **Electron-beam parametric amplifier for the 200 Mc/s region** *November 1960*

J. A. LANE, M.SC., *and* D. M. EVANS, PH.D., B.SC. PAPER 3392E **Design and performance of transverse-film bolometers in rectangular waveguides** *January 1961*

### PART C. MONOGRAPHS (SEPTEMBER 1960)

*See the Journal for September 1960, p. 561*

# PAPER AND MONOGRAPHS
## *published individually this month*

*Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available, they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.*

*In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings, become available, price 2s., within two months of their appearance in the Proceedings.*

*Applications quoting the serial number of the paper, monograph or reprint as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary of The Institution. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.*

*Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint, as this is the final and correct version and includes the discussion.*

## PAPER

**Comparison of argon, krypton and xenon as admixtures in neon glow-discharge reference tubes** *Paper* 3420E, *Part B*

F. A. BENSON, D.ENG., PH.D., *and* G. P. BURDETT, B.ENG.

SPECIAL glow-discharge reference tubes containing neon–krypton, neon–xenon, neon–0·3% argon–krypton and neon–0·3% argon–xenon mixtures have been examined, the krypton or xenon content varying from 0·001 to 1%. The tubes had molybdenum electrodes, and the total gas pressure was either 40 or 20 mm Hg. The striking voltage, running-voltage/current, running-voltage/temperature, initial drift, impedance/frequency and noise-voltage/current characteristics have been determined.

The results of the studies are presented and discussed and are compared with those previously obtained for neon–argon tubes. It is concluded that certain desired tube characteristics can frequently be obtained by the correct choice of gas mixture.

*To be read on the 8th May 1961*

## MONOGRAPHS

**Travelling-wave analysis of generalized networks** *Monograph* 425E

J. ZAWELS, PH.D.

THE behaviour of networks, whether lumped, distributed, active or passive, is analysed from a fundamental travelling-wave point of view. Generalized wave parameters are derived for a 2-port network, from which image, conjugate and iterative parameters follow as special cases. The relationships of these to short- and open-circuit parameters are also given.

A matrix organization of waves in a multi-port network is next presented which distinguishes between waves internal and external to the network. Through special transformations, voltage- and power-gain matrices are derived, and their relationship to the conventional scattering matrix is shown.

Finally, a visual representation of the wave-trains set up in cascaded stages is given in the form of wave flow diagrams, reminiscent of Mason's feedback graphs.

**Optimum sampled-data control** *Monograph* 426M

R. JACKSON, M.A.

A METHOD of rendering feedback control systems amenable to treatment by the Wiener theory is applied to the case in which the controller operates on a sampled measurement. An explicit expression is obtained for the minimum attainable mean-square error for

certain classes of system transfer functions and disturbance power spectra, and the form of the optimum controller is derived.

The results show the inherent limitations in controllability imposed by the structure of the controlled system and by the sampling process.

**The stability of permanent magnets** *Monograph* 427M

C. E. WEBB, B.SC.(ENG.)

THE author describes tests made to compare the magnetic stability of representative martensitic and precipitation-hardening (isotropic and anisotropic) permanent-magnet materials. The weakening of magnets with time after magnetization, when left as free from disturbance as possible, was measured over a period of about three years, both on unstabilized magnets and on magnets artificially stabilized by weakening them 1% or 5% by applying demagnetizing fields. Anisotropic alloys were found to be much more stable than isotropic alloys, the stability of Columax being outstanding. Alnico, in spite of its much higher coercive force, was not more stable than the martensitic steels.

The effect on stability of the working-point of the permanent-magnet material was also examined and found to be small above the $(BH)_{max}$ point on the demagnetization curve. Below the $(BH)_{max}$ point, however, the stability of both isotropic and anisotropic materials was considerably reduced.

Further tests were made on the effects of heating at various temperatures up to 220°C and of mechanical stress and impact. Stability in high-temperature treatment is only roughly related to stability in time tests. The results of the mechanical tests were inconclusive, as the magnet assemblies available, designed primarily for long-term tests, were not suitable for subjection to severe mechanical treatment.

# OBITUARY

## JAMES WILLIAM ARTHUR

James William Arthur who died on the 17th October 1960 was born on the 14th June 1882 and devoted his life to the service of the electricity undertaking at Reading. He was educated at Russell Hill School, Purley, and part-time at the South Western Polytechnic while apprenticed to Peter Brotherhood, London, for five years.

He joined Reading Electric Supply Co. in 1904 as assistant mains engineer and rapidly attained the position of chief technical assistant, his main interest and responsibility being on the generating side.

'J. A.', as he was affectionately known, never sought the limelight, but it was his wise counsel which contributed so much to building the successful and prospering undertaking which Reading was at the time of his retirement in 1947. When the undertaking was acquired by Reading Corporation in 1933, he became the engineer and manager.

Although a strict disciplinarian, he was held in the highest respect and regard by his staff, and it was a tribute to his memory that the funeral at Caversham was attended by so many of his old colleagues.

He was very interested in sport: for a long time he was a regular follower of the fortunes of Reading Football Club, and he was a keen angler. He is survived by his widow and a daughter. His son, Major Arthur, died suddenly during the Second World War.

He joined The Institution as an Associate Member in 1920 and was elected a Member in 1934. H. R. J. B.

## STANLEY FENELEY BICKELL

Stanley Feneley Bickell who died on the 30th September 1960 at Frampton Cotterell, near Bristol, was born in Gilliamham on the 27th April 1898. He was educated at Devonport High School and at Faraday House. During the 1914–18 War he served as chief petty officer, Torpedo School, H.M.S. *Defiance*, from 1917 to 1918 and was then drafted to the Dover Patrol. He was discharged in January 1919 and returned to Faraday House to complete his course.

In 1920 he joined Brompton and Kensington Accessories Co., London, first as assistant works manager and later as manager and designer. From 1926 to 1933 he was manager of the heating and cooking department at Revo Electric Co., Tipton, Staffordshire, after which he was for three years with Falk, Stadelmann and Co. in a similar capacity. In 1936 he joined British National Electrics Ltd. as works manager and designer, where he remained until 1946. He then became chief engineer with Parnall (Yate) Ltd., retiring through ill-health in 1959.

He was a prolific inventor, with many patents to his credit, and will be best remembered as the designer of the first resettable automatic electric kettle and for his work on transformer-operated boiling plates.

He had a lively literary style, and from 1934 to 1941 he wrote monthly articles for *The Electrician* under the pseudonym of 'Nichro' and occasional articles for the *Electrical Times* under his own name.

He is survived by his widow, three sons, who all have embarked on engineering careers, and a daughter.

He joined The Institution as a Student in 1918 and was elected an Associate Member in 1924 and a Member in 1930. G. R.

## WARD FOLLETT DAVIDSON

Ward Follett Davidson, M.SC., who died on the 12th July 1960 was born at Commonwealth, Wisconsin, U.S.A., on the 21st October 1890. He was educated at the University of Michigan, where he received the B.S.E. degree, and at the University of Michigan Graduate School, where in 1920 he was awarded the M.Sc. degree.

He obtained his early experience with Westinghouse Electric and Manufacturing Co., Pittsburgh, before serving with the U.S. Army in France and Germany during the 1914–18 War, attaining the rank of captain. He returned to the University of Michigan in 1920 as assistant professor in electrical engineering.

In 1922 he became director of research, Brooklyn Edison Co., which later merged to form Consolidated Edison Co. His contributions ranged from the development of high-pressure high-temperature boilers to making the first scientific analysis of soot fall-out in New York City. He retired in 1955.

He received the Presidential Certificate of Merit after the Second World War for his work with the National Defence Research Committee. In 1950 he was a delegate to the World Conference on Atomic Power in London.

He is survived by his widow, a son and a daughter.

He joined The Institution as an Associate Member in 1925 and was elected a Member in 1928. His paper entitled 'Plant co-ordination—an example of co-operation' was published in the *Journal* in 1949. He was a Member of The Institution of Mechanical Engineers and a past-president of the American Institute of Electrical Engineers.

## GUY LYNDON DRURY

Guy Lyndon Drury who was born at Rathgar, Dublin, on the 9th April 1878 died on the 25th August 1960. He was educated at St. Stephen's Green School, Dublin, and at the Royal College of Science, Dublin, where he studied applied physics and electrical engineering.

Leaving college in 1898, he received practical training with Dublin United Tramways, which were then being converted for electrical working. On the opening of Ringsend power station in 1901 he was made assistant engineer in charge of the station (4800 kW), which was at that time the largest traction station in Britain. In 1903 he was appointed engineer-in-charge.

In 1904 he joined the North Eastern Railway at York, in charge of the electrical equipment of the rolling-stock for the North Tyneside branch, and later in the same year was appointed electric car shed superintendent at Newcastle upon Tyne, in charge of the electric rolling-stock, motormen and train working.

Under the late Sir Vincent Raven, he was responsible for the electrical equipment and putting into service of the 1500 volt electric locomotives on the Newport–Shildon line. He also represented the N.E.R. on several British Electrical Standards Association committees, including that on traction motors. During the 1914–18 War he was on loan to the Admiralty for special work.

## Obituary (continued)

In 1920 he was appointed carriage and wagon works manager for the Northern Division of the N.E.R. After the railway amalgamation, he was, in 1924, appointed assistant electrical engineer, N.E. Area, L.N.E.R., with headquarters at Darlington, and was in charge of traction, power and lighting in the area, a position which he held until he retired in 1938.

In his younger days he was a keen walker, fond of travelling, and spent many of his vacations in Europe. He was always a keen ornithologist and spent much of his retirement in Newcastle recording the movements of birds and studying entomology.

His wife died in 1955.

He joined The Institution as a Student in 1899 and was elected an Associate in 1900, an Associate Member in 1904 and a Member in 1921. He served on the Newcastle Local Centre Committee in 1913–14 and on the North-Eastern Centre Committee from 1920 to 1922. A. E. S.

### LAURENCE JOSEPH KETTLE

Laurence Joseph Kettle, D.SC., who died in Dublin on the 27th August 1960 was born at Malahide, Co. Dublin, on the 27th February 1878, son of Andrew Kettle, M.P. He received his early education in the O'Connell Schools, Dublin, at Clongowes Wood College, and at Faraday House, where he gained the Maxwell Scholarship. His varied practical training and early experience were gained with R. Stephenson, Newcastle upon Tyne, Maschinenfabrik Oerlikon, Switzerland, Société des Forces Électriques de la Goule, Switzerland, and the General Electric Co.

He returned to Dublin in 1906 to join the corporation as works superintendent engineer and became deputy city electrical engineer in 1911 and engineer and manager in 1918. When the undertaking was taken over by the Electricity Supply Board (Ireland) in 1929, he was appointed adviser to the board. From 1934 until his retirement in 1950 he was a member of the board.

He also applied his engineering training and judgment towards promoting the development of Irish national resources. His experience as the technical representative in Ireland of the Board of Trade Coal Department led him to give full support to all projects for the economical use of fuel. He acted on the Water Power Board of Ireland Sub-Committee from 1916 to 1918.

His retirement allowed him to give his energies towards the greater application of science to and the development of Irish industrial projects. As President of The Institution of Civil Engineers (Ireland) from 1932 to 1934, he delivered an address calling for an investigation into the scientific problems of agriculture, a survey for drainage and a scheme for rural electrification. While president, he organized in 1934 a discussion on the organization of industrial research in Ireland. In that year he was appointed chairman of the newly formed Industrial Research Council and held office until 1957. He became the first chairman of the Industrial Research Committee, resigning in 1947. The movement for industrial research in Ireland owed much to his patient service.

On the formation of the Industrial Credit Co. in 1933, to promote and finance by State aid industrial undertakings, he was appointed and remained a director.

In 1958 he edited his father's memoirs of the period, 'The material for victory', giving first-hand notes of Parnell at times of crises. In 1912 he took a leading part in the formation of the Irish Volunteers. In 1933 friends and admirers of his public services made him a presentation, including his portrait by John Keating, now in the municipal art gallery. In 1938 the National University of Ireland conferred on him the degree of D.Sc. *honoris causa*.

He was a founder-member of the World Power Conference and secretary of the Irish Committee for many years, a member of the Irish Committee of The Institution of Mechanical Engineers and a Fellow of the Institute of Fuel.

He joined The Institution as a Student in 1899 and was elected an Associate in 1902, an Associate Member in 1906 and a Member in 1912. He served on the Dublin Local Centre Committee in 1913–14 and on the Irish Centre Committee from 1926 to 1931, being chairman from 1926 to 1928 and serving as honorary treasurer from 1933 to 1934. F. H.

### JAMES RANKIN

Lt.-Col. James Rankin, O.B.E., who was born in Cardiff on the 1st March 1892 died on the 9th October 1960. He was educated at St. Mary's Hall Private School, Cardiff, and as a youth was interested in athletics, specializing in water polo and Rugby football. He was studying law when, in 1914, he joined the 6th Battalion of the Welch Regiment and served in France, being invalided out in 1918.

Returning to civilian life, he qualified as a solicitor while employed by the North Wales Power Co. Later he became secretary to G. V. Twiss and Partners. When the British Power and Light Corporation was formed in 1929, he became secretary of this group, which included the North Wales Power Co. By 1940 he was a director of British Power and Light and general manager of the group.

On the nationalization of the electricity supply industry in 1948, he was appointed secretary of the Merseyside and North Wales Electricity Board, and became its deputy chairman in 1953, a position which he held until his retirement in 1959.

He was appointed an Officer of the Order of the British Empire in 1952 for special service to the National Savings Movement in North Wales.

He was very well known throughout the Principality, where he undertook with distinction many public duties. He served as a member and as chairman of the North Wales District Committee of the Welsh Board for Industry and as a member and president of the Industrial Association of Wales and Monmouthshire. A man of great personal charm and quiet persuasive manner, he was held in the highest esteem by all those who worked with and for him. His contribution to the administrative efficiency of the electricity supply service will be a lasting memorial.

He is survived by his widow.

He was elected a Companion of The Institution in 1947. J. E.

### MAURICE VERNON RATCLIFFE

Maurice Vernon Ratcliffe, B.SC.(ENG.), who died on the 25th October 1960 near Rio de Janeiro, Brazil, as the result of a helicopter crash while making an electric-power-transmission survey for his firm, was born on the 1st February 1909. He was educated at Alleyn's School, Dulwich, and at King's College, London, where he graduated in 1930 with first-class honours in electrical engineering. He was awarded a College Diploma and the Siemens Prize in electrical engineering.

He joined Kennedy and Donkin in 1930 and for the next 12 years played an increasingly important part in the design and supervision of construction of the South-West England and South Wales Grid schemes. At the conclusion of his work in that area, the Board's staff in Bristol made him a presentation as an appreciation of his work for them.

From Bristol he went to Edinburgh in 1943 as Kennedy and Donkin's first resident engineer for their work for the North of Scotland Hydro-Electric Board, remaining there until 1951 when he returned to London to take charge of all electric-power-transmission design and construction for his firm.

Much of his work was oversea, and during the past ten years he had twice visited Uganda, as well as India, Western Canada and South America in his role of transmission design engineer.

His chief interests outside his work were his family and the house and garden in which they lived, and he was never so happy as when at home with them. He was a fine engineer who combined a high degree of theoretical knowledge with great practical sense. The spirit of friendly helpfulness that he brought to all co-operative endeavour was instantly evident and appreciated by his colleagues. He combined a charm of manner and quiet purposefulness that made him welcome and respected wherever he went, and his untimely passing leaves a great sorrow in the hearts and minds of all who knew him.

He joined The Institution as a Student in 1930 and was elected an Associate Member in 1935 and a Member in 1942. B. D.

### LORD VERULAM

James Brabazon Grimston, M.A., 5th Earl of Verulam, who died on the 13th October 1960 was born in London on the 11th October 1910. He was educated at Eton College and at Christ Church, Oxford, where he read natural history and languages. The years 1932 to 1935 were spent largely in Austria and Germany, and it was during this period that he acquired the remarkable knowledge of non-ferrous metallurgy and industrial process which contributed to the expansion of the Enfield group of companies of which his father was chairman. As managing director of Enfield Cables Ltd. during three years of war, his presence day and night in a much bombed factory won for him the devotion of all who worked there. He became chairman of the group in 1949 and held the position at the time of his death.

Verulam travelled a great deal in the interest of his companies and was an unselfish competitor in that his experience was readily

available to others. Typical of his desire to share the benefit of these journeys was the paper entitled 'Some projects favourable to direct-current transmission, and the role of the British electrical industry in relation thereto', urging British industry to take the initiative in the development of direct-current transmission, which, together with F. J. Erroll, M.A., M.P., he presented to The Institution in 1948. Since he preached always that the physical separation of Commonwealth nations need not be a barrier to co-operation, it was probably not altogether accidental that Verulam should be in Toronto on the night the paper was due to be presented. This was surely the first occasion on which the principal speaker at an Ordinary Meeting had been in the Western Hemisphere, and few of those present in the packed Lecture Theatre will forget the urgency in the voice which came clearly by radiotelephone across the Atlantic when he gave a brief introduction. It was a source of great satisfaction to him that much that he then advocated was accepted as practical in his lifetime. The paper was published in 1949 in the *Journal*. He was elected a Companion in 1949. S. C.

# SOME RECENT BOOKS

## ELECTROMAGNETIC ENERGY TRANSMISSION AND RADIATION

R. B. ADLER, L. J. CHU and R. M. FANO

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1960. 621 PP. £5 16S.

THIS book, forming as it does part of the 'core corriculum' of a teaching scheme, is primarily concerned with fundamental ideas and concepts rather than with practical devices. The authors have therefore been able to consider, from different viewpoints and in greater detail than would otherwise have been possible, some of the fundamental aspects of electromagnetic-wave behaviour; and it is in depth of discussion rather than in diversity that the strength of the work lies.

As the title implies, it deals mainly with transmission phenomena and contains a very full treatment of transmission lines, both lossless and dissipative, from a transient as well as from a steady-state point of view. This is followed by three sections on plane waves, most of which the authors consider to be beyond undergraduate level; and these, together with the transmission-line material, comprise the major part of the text.

In contrast, one wonders whether 'radiation' should have a place in the title, since the final chapter, which deals with this, is one of the shortest in the volume and, in comparison with the treatment of earlier topics, does little more than introduce its subject. C. S. GLEDHILL

## PROGRESS IN AUTOMATION—Vol. 1

A. D. BOOTH (*Editor*)

BUTTERWORTHS. 1960. 231 PP. £2 2S.

THIS is intended to be 'the first of several volumes which will, from time to time, detail the progress which has been made in this field'.

The introduction by A. D. Booth includes a few historical notes and some definitions of codes and of control terminology. Six papers on 'methods' follow. First, 'Analogue-to-digital conversion techniques' by G. T. Herring surveys the principles and gives a detailed description of a particular high-speed convertor. Next, J. M. Keating, in 'Applications of electronics to process-control systems', discusses present-day ideas on the control of complete plants.

K. J. Coppin, in 'A basic system of position control for the traversing tables of machine tools', describes a machine which uses the leadscrew as the measuring element; and H. J. Finden explains the Inductosyn device for position measurement. The 'methods' section concludes with two surveys of nucleonics: a general article by T. B. Rowley and one on fluid-density measurement by A. E. M. Hodgson.

The last part contains four contributions on 'application'. The Ferranti and E.M.I. systems of machine-tool control are described by D. T. N. Williamson and F. W. Hartley respectively; the latter devotes half his space to a useful survey of all commercially developed systems. The comparison between these papers makes the most interesting reading in the book. G. Syke writes on 'Automatic control in the manufacture of steel strip' and J. A. Sargrove on 'Automatic inspection'.

One cannot cavil at selections or omissions in a work which makes no claims to completeness, but the feeling persists that the field is too wide for a single series and that earlier volumes will be out of date before any one part of it has been thoroughly considered. In this text, only machine-tool control is treated in sufficient detail to reveal the stimulating differences of opinion and emphasis in articles by the proponents of competing systems; perhaps subsequent volumes could take one such topic and treat it fully.

The quality of the writing is generally good, as is the format. The indexes, however, are not of much help in locating subject material. N. REAM

## TELEMETERING SYSTEMS

P. A. BORDEN and W. J. MAYO-WELLS

NEW YORK: REINHOLD. LONDON: CHAPMAN AND HALL. 1959. 349 PP. £3 8S.

THE science and technology of telemetering have made impressive strides as relevant parts of missile and space-research projects. Though environmental conditions and operational requirements differ considerably from those in industrial telemetering, much of the technology is common to both.

A broad survey of the whole subject with some emphasis on recently declassified information should thus be welcomed.

About one-third of the volume—chapters 2 to 8—describes 'Systems of telemetering' with many examples, under the headings of current, voltage, frequency, position and impulse systems. The treatment is sketchy, and many of the classifications are arbitrary. In the following chapters—9 to 12—the reader is taken for a ramble through the related fields (or

jungles?) of measuring pick-ups, transducers, transmission links, data handling and computation.

There is a useful chapter (14) on 'Selection and application of telemetering systems', in which the relevant considerations for choosing the right scheme to meet specified requirements are critically discussed. The closing section deals with reliability and testing.

The book should be of some use to engineers, versed in measurement and communication, who want to get a broad picture of present techniques and practices in both missile and industrial telemetering. It leaves much to be desired in respect of clarity and accuracy. The hope of the authors, 'that the reader will be able to acquire a working knowledge of the principles and practices of present-day telemetering', may not be fully achieved, but he will at least have a good idea of what it is all about. G. SYKE

## THE TESTING OF ELECTRICAL MACHINES

### L. H. A. CARR

MACDONALD. 1960. 299 PP. £2 10S.

THE late L. H. A. Carr began to write this towards the end of a long life, spent largely in the design of electrical machines. Nobody who knew him either as a machine designer or in one of his numerous other activities would expect a book by his hand to be anything but lucid and accurate. It contains much useful advice derived from many years' experience of the difficulties which can arise on a test-bed. Design engineers as well as testers would profit from reading it.

No reference is made to the testing of 3-phase commutator machines and single-phase motors. The explanation given is that the text had to be kept within a reasonable size. Perhaps in a later revision, consideration could be given to making room for these special types of machine by omitting some sections which appear to be slightly outside the scope of electrical testing. Among these are Chapter 4, on the operational theory of the synchronous machine; the first part of Chapter 9, on further synchronous theory; and parts of Chapter 14, dealing with mechanical tests on the material of turbogenerator rotors.

There is a noticeable unbalance at present between the great deal of space devoted to the theory of a.c. motors and generators, and the almost complete disregard of the theory of d.c. machines. C. P. HOLDER

## A PHYSICS ANTHOLOGY

### N. CLARKE (*Editor*)

CHAPMAN AND HALL. 1960. 323 PP. 35S.

THIS volume will be of interest to engineers as well as to physicists, and they should not neglect it on account of its title. It is not about physics, but rather about the relationship of physicists to the wider world. It consists of 23 articles that have been published during recent years in the *Bulletin of the Physical Society*. They are by distinguished persons and deal with general topics from ethics to employment.

The book is worth reading by all who are concerned with the education of physicists or engineers, or who are interested in the philosophical question of the place of physics in human affairs. In any anthology a reader may be selective, and here there is a variety of both interest and entertainment.

In so far as there is a main theme, it is that of the mental distress of all the less-robot-like physicists about the rift between science and humanity. Physicists devote themselves with single-mindedness to the advancement of knowledge, cherishing the underlying thought that this will benefit man's estate. But when they put their heads out of their laboratory windows, they may note that, among other things, their work may be knocking away traditional props of religion and morality, be providing means by which power-seekers may bring a tortured death to millions, or be skimming off the cream of intellectual youth into specialisms that make them somehow rather less than fully human. At the very least, these leading physicists feel themselves to be fiddling while Rome burns, and are agonized with impotence in face of the vast irrationality of it all.

In this collection may be found many moving expressions of the misgivings of intelligent and sensitive men, whose intellectual honesty prevents their consciences being placated by the simple myths and loyalties that suffice for lesser minds. One's first reaction may be disappointment that they go little further than to focus the problem.

Perhaps, however, their thoughts have gone further than is immediately obvious, just because there is remarkable agreement about the shape of the problem. The physicists may have displaced man from the centre of the universe. They are now showing equal honesty in displacing physics from the centre of significance for progress. There seems to be general agreement that, in human affairs, knowledge and reason are but tools. The essential man is a complex of motives, purposes and passions, which is part of our activity of living and feeling, and which uses reason but can never be subsumed within it, being essentially of another kind.

But having made this great self-abnegating observation, that solution of the world's problems is not the solution of a problem in physics, the contributors to this anthology seem disappointingly reluctant to reach conclusions. It is evident that our present problem is to understand ourselves, and whether or not we understand the parity relationships of the 'ultimate' particles is almost an irrelevance. The quality of human personality and experience seems to be capable of kaleidoscopic variety, by the structuring of its primitive elements, and to be capable of indefinite progress. It is this art, which involves other faculties than observation and reason, that needs to be cultivated.

It is a tribute to this anthology that it cannot fail to stimulate such thoughts, although various readers may draw various conclusions.

Incidentally, the slander that physicists cannot write is refuted by many of these essays. It is noteworthy that many of the contributions from physicists are more lucid, precise and readable than the several contributions by classicists included in the selection.

It may be hoped that some similar collection in five or ten years' time will show that the movement of thought among physicists on these broader topics has continued, and has stimulated an effective impact on our educational practices.

A. TUSTIN

## MATHEMATICAL PROGRAMMING AND ELECTRICAL NETWORKS

J. B. DENNIS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 186 PP. 36S.

THIS monograph is concerned with a research study undertaken by the author at the Massachusetts Institute of Technology, and deals with the relations between mathematical programming and electric-circuit principles.

An early chapter introduces the nature of mathematical-programming problems and considers the special cases of linear and quadratic programmes. It is then shown that an electrical network having voltage sources, current sources, diodes and transformers may theoretically be used to determine the optimal solution of a linear-programming problem, and that the addition of resistors produces an equivalence between quadratic programmes with linear constraints and electrical networks. In relation to programming, the author discusses the maximum-flow and the shortest-path problems, together with equivalent electrical models.

In later sections, the concept of a break-point curve (defined as a continuous curve consisting of straight-line segments of non-negative slope), arising from the consideration of suitable electrical networks, leads to algorithms applicable to the solution of general linear- and quadratic-programming problems.

The work concludes with a number of appendixes giving proofs of fundamental theorems. It will be of interest to those desiring a physical interpretation of some of the main theoretical ideas of programming. F. H. JACKSON

## ELECTRONIC EQUIPMENT RELIABILITY

G. W. A. DUMMER and N. GRIFFIN

PITMAN. 1960. 274 PP. £2 5S.

MR. DUMMER is well known for the hard work he has put into getting electronic components developed to meet the exacting needs of the Services, and the advice that he and his co-author give in this book is governed by the Services' outlook. It is at least arguable that computers, broadcasting transmitters, and long-distance telephone circuits are more reliable than military equipment, but the total space devoted to all of them is about one page. This is as if a publication on the reliability of cars were devoted entirely to the technique of motor-racing.

The text is largely compiled from the reports issued by Government and other agencies carrying out tests on components; the quoted references are nearly all American. There is some attempt to summarize the vast quantities of data, but not enough. Nothing in this work will tell the reader what degree of reliability may reasonably be expected of electronic equipment in ordinary surroundings.

It is attractively produced, and the standard of proof-reading seems generally good; but a misleading error occurs in the table on p. 256, and one reference has errors in both the author's name and his initials.

Within the limitations mentioned, the volume is a mine of information; but its usefulness is for reference on matters of detail, not for obtaining a general view of the situation.

A. C. LYNCH

## TRANSISTOR CIRCUIT ANALYSIS AND DESIGN

F. C. FITCHEN

PRINCETON: VAN NOSTRAND. 1960. 356 PP. £2 16S.

THIS publication sets out to introduce the subject both to students proceeding to a degree or embarking on a career in the field, and to anyone switching from the application of valves. It does so on a scale sufficient to ensure coherence while generally retaining interest. Once the introduction and physics have been disposed of—the latter too briefly to be of much value—an even pace and standard are set. The descriptive sections are clear and the analytical are full enough not to halt the reader. The more important ideas are never rushed, and their practical implications are stressed by way of numerical examples. In consequence, the coverage is less than one finds in some works of equal size.

The emphasis is on single- and multi-stage small-signal amplifiers both without and with feedback, particularly for communication, with supporting chapters on methods of biasing, oscillators and large-signal amplifiers. A section is devoted, early on, to equivalent circuits, that untidy part of the subject; although the simple T-network and the low-frequency *h*-parameters get sufficient attention, much more mention should have been made of reactive components and the frequency-dependence of parameters. Pulse circuits are allotted only 20 pages, an inadequate fraction of the volume. Every chapter concludes with ample examples, mostly with practical significance, and students would do well to tackle them in moderation. All in all, the book achieves much of its object. J. R. TILLMAN

## RADIO AIDS TO CIVIL AVIATION

R. F. HANSFORD (*Editor*)

LONDON: HEYWOOD. 1960. 623 PP. £6 6S.

MR. HANSFORD'S work is the first to cover in such a comprehensive manner the characteristics of the several systems now in use or envisaged and their contribution to the over-all air-traffic-control pattern. Furthermore, it gives due weight to problems of communication, particularly air–ground–air, which are sometimes neglected for the more obvious requirements of navigational aids and ground radar systems.

The only major query is the desirability of including the opening chapter on 'Principles of radio'. This is, of course, conditioned by the type of reader for whom the author is writing. In his preface he says that 'the book is aimed particularly at the system designer and the operational planner . . . [and is] not . . . for the circuit designer'. Broadly speaking, sufficient detail on system characteristics is included elsewhere in the book to satisfy this requirement.

It is also doubtful whether the I.C.A.O. annexes and the brief historical section are necessary, while certainly the 'catalogue' information on commercial equipments could have been omitted. The price of the volume is such that it is

unlikely to be bought by many individuals; and the organizations which will buy it will almost certainly already have this information.

There are excellent chapters on aids to air traffic control, communication systems and present trends, although much of the material was obviously written three or four years ago. Some editing has been done to bring the text up to date, but there are one or two omissions: for example, a more detailed discussion might have been included on the possibility of using Doppler plus an airborne computer for long-range navigation and distance-to-go.

Nevertheless, these are minor blemishes in what should become a standard reference work; and it is hoped that, if there is a second edition, it will take account of developments during the last few years.

B. J. O'KANE

## DYNAMIC PROGRAMMING AND MARKOV PROCESSES

R. A. HOWARD

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1960. 136 PP. £2 6S.

THE 'programming' with which this book is concerned is that of a sequence of operations, as exemplified by the maintenance and replacement of machinery, the tactics at successive points in a game of baseball, and machine-loading in a factory. It thus falls within the field of operational research, and provides a technique for decision-making in a class of problems. The reference to Markov processes in the title is to be read as a limitation of scope, since the class of problems handled comprises those in which a system has a set of discrete states, each of which is sufficient to specify the probabilities of transitions to future states without reference to past events.

This absence of 'memory' of past events seems unrealistic in some cases. In one example, the profitability of a business from week to week is estimated in terms of decisions for and against, first, advertising and, secondly, research; but even in so simple a business as toy-making, one would expect advertising and research to have effects lasting over more than one step in the history of the enterprise.

However, the mathematical analysis is presented with admirable clarity, and no engineering graduate need have anxiety on this score. It includes, incidentally, an introduction to the $z$-transform, which is also used for sampled-data systems in communication and automatic control.

D. A. BELL

## INFORMATION PROCESSING

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON INFORMATION PROCESSING, UNESCO, PARIS, 15–20 JUNE 1959

PARIS: UNESCO. MUNICH: R. OLDENBURG. LONDON: BUTTERWORTHS. 1960. 520 PP. £7 7S.

THIS is the collected and edited version of the papers and discussions at the conference. It is a large and handsome volume, packed with material on almost every aspect of the computer art.

The arrangement of contents follows the actual conference sessions, the topics covered being numerical analysis, common symbolic computer languages, machine translation, pattern recognition and machine learning, logical design, techniques of the future, digital versus analogue computation, error detection and correction, and information storage and retrieval.

Almost all the sections contain information which will interest the engineer, although actual details of 'hardware' are far less in evidence than was the case with the roughly equivalent Vol. 103B, Supplements 1–3, of the *Proceedings* of The Institution. Naturally, the 'perennials' appear in this collection as elsewhere, but the volume of new material is such that all electrical engineers will wish to read it, even if the price is such that most will be unable to have it in their own libraries.

A. D. BOOTH

## THE SCATTERING AND DIFFRACTION OF WAVES

R. W. P. KING and T. T. WU

CAMBRIDGE, MASS.: HARVARD UNIVERSITY PRESS. LONDON: OXFORD UNIVERSITY PRESS. 1959. 218 PP. 32S. 6D.

THE potential reader should bear in mind that this is one of the Harvard Monographs in Applied Science, which by definition are devoted primarily to reports of university research; in the present instance, a particular aspect is treated of the programme of fundamental research in electromagnetic radiation that has been in progress at the Cruft Laboratory for many years.

The first part is devoted to theoretical studies of diffraction and scattering by circular cylinders, spheres, discs and strips, and of transmission through apertures, in which the reader must be content to accept many elaborate mathematical expansions on trust, unless he has access to a large number of the Cruft technical reports referred to in numerous footnotes. The remainder is similarly concerned mostly with the methods that have been developed at the Laboratory for measuring the back-scattering cross-sections and the diffraction fields of obstacles.

The purely descriptive introductory chapter on theory and experiment is an extremely good review of the formidable problems associated with the reflection of electromagnetic radiation from obstacles of complex shape, including the determination of the field set up by a practical source and the influence of the measuring probe on the field. It is somewhat disappointing that, in the sequel, so little is said about the reduction of results to simple terms for the engineer who may feel that the theoretical sections are interesting but erudite academic exercises. For instance, he will find nothing about the approximate methods that have to be used in the prediction of television service areas by the assessment of diffraction losses over complex ground-profiles.

In essence, the book is a description of an elaborate attack on the difficult mathematics of the problem with the aid of modern computing methods, whereby many curves relating to a number of idealized situations have been obtained and compared with the results of carefully controlled experiments. As such, it is the record of a remarkable and concentrated

research effort of great interest to the limited number who will appreciate its intricacies. Incidentally, although the production is good, some of the diagrams contain a confusing amount of detail that makes them difficult to interpret.

The authors have indicated that the mathematical solutions have their application in acoustical work, but the presentation is almost entirely in terms of polarized radio waves and is unlikely to appeal to any acoustical engineer unfamiliar with electromagnetic theory. For this reason, it would have been better to have added 'electromagnetic' to the title, for it is obvious that the authors themselves are not working in the acoustical field. G. MILLINGTON

## ARTIFICIAL EARTH SATELLITES—Vols. 1 and 2

L. V. KURNOSOVA (*Editor*)

NEW YORK: PLENUM PRESS. LONDON: CHAPMAN AND HALL. 1960. 107 PP. $9.50

AT the 5th Assembly of the I.G.Y. Committee, held in Moscow in August 1958, scientists from the Soviet Union presented a series of papers on results they had obtained in the investigation of the upper atmosphere by using rockets and three artificial satellites. This book contains these papers translated into English. They are concerned with cosmic rays, atmospheric density, electron concentration in the ionosphere, geomagnetism, the dynamics of satellite motion, and the responses of animals travelling in satellites.

Many of these short papers now read like preliminary accounts of knowledge which is now well known, but that is only to be expected in this rapidly advancing branch of science. It is of value to have them collected into one volume in a form accessible to English-speaking workers. These workers will notice the large proportion of references to papers in English and may be led to consider how far it is their custom to read the corresponding Russian scientific literature in detail. J. A. RATCLIFFE

## THE CATHODE RAY TUBE MEMORY OF THE HIGH-SPEED ELECTRONIC COMPUTER OF THE U.S.S.R. ACADEMY OF SCIENCES

V. N. LAUT and L. A. LYUBOVICH

PERGAMON PRESS. 1960. 90 PP. 35S.

THIS work describes the barrier-grid storage-tube memory of the BESM I computer. It has the character of a final report on a completed project, and thus examines in much detail work which was done a long time ago.

The circuit problems involved in using barrier-grid storage tubes are discussed, and the authors in most cases give their reasons for choosing particular solutions to these problems. The physical construction of the store and the procedures used for testing it are also studied, and there is a useful final chapter on experience of operation. In this last section (which was presumably written some time after completion of the design work) we read '. . . until now there are not any memories with ferromagnetic storage elements in operation . . .'. This statement, which appears to refer to the world and not just to the Soviet Union, gives some indication of when the text was written. There is no mention of the fact (reported elsewhere) that, some time before the spring of 1959, the memory described was superseded in BESM I by a ferrite-core memory.

Although originally written some time ago, the book bears signs of hurried publication, and the reproduction of the half-tone illustrations is disappointing. It should, however, be of some interest to anyone proposing to use barrier-grid tubes for digital storage. E. H. COOKE-YARBOROUGH

## DIGITAL COMPUTER AND CONTROL ENGINEERING

R. S. LEDLEY

McGRAW-HILL. 1960. 835 PP. £5 12S. 6D.

THIS is a remarkable work. In the preface, the author states that his purpose is to fill the need for a comprehensive elementary engineering textbook in the large and still-rapidly-growing field of digital computers and controls. In parenthesis, he explains that the term 'control' is used to emphasize that digital control and digital computers are based on the same principles. He goes on to say, 'Within the first five years after he earns his degree, almost every electrical engineer will deal with some phase of digital circuitry. Therefore a course on digital computers is required for all candidates for the bachelor of electrical engineering degree at The George Washington University. This is indicative of a trend in engineering schools throughout the country.'

The book is based on a one-year course given by the author to senior engineering students at The George Washington University. It covers the over-all design of digital systems, the logical design of digital circuits, and the electronic design of digital circuits. I feel that the volume must contain more material than was included in the author's course, for it consists of 800 densely packed pages. Most of the material is of a typical textbook character, but there are frequent sections (in small type) that are more of the kind one finds in engineering reference handbooks.

The author has adopted the method of teaching by example, rather than by generalized exposition. He shows, I think, that this method can be very successful in teaching engineering technology, especially when the examples are up to date. It is not, however, so successful in the chapter that deals with numerical analysis; I confess that I found this section somewhat off-beat, and I do not feel that the student will obtain from it a true appreciation of fundamentals. On the other hand, the treatment of programming seems to me very suitable for students whose primary interest is in the design of digital systems, although I would not choose it as an introduction for those who intend to be professional programmers.

I cannot claim to have read every word of the text, but I have dipped into it extensively and have been everywhere impressed by the encyclopedic knowledge shown by the author and his two collaborators, and by their grasp of the subject—to say nothing of their industry. If it is true that American universities are beginning to put all students of light-current electrical engineering through a course of this character, the outlook for digital control and computer engineering in the United States is indeed bright.

M. V. WILKES

## SELF-SATURATING MAGNETIC AMPLIFIERS

G. E. LYNN, T. J. PULA, J. F. RINGELMAN and F. G. TIMMEL

McGRAW-HILL. 1960. 217 PP. £3 2S.

THE material for this book was derived from a course of lectures given to practising engineers in the authors' company. This probably explains the verbose style, which is particularly unfortunate when dealing with a subject where concise, lucid writing would be of great value.

The authors' wide experience in aircraft applications has led to a certain bias in the choice of examples, which are generally based on a 400c/s supply frequency and the use of expensive, but high-performance, core materials. Silicon-iron is only mentioned as necessarily used in high-power amplifiers with a 50–60c/s supply. Ferrites, briefly and somewhat inaccurately described in the chapter on magnetic materials, are otherwise ignored.

The volume can hardly be recommended to the student as a textbook, but should be valuable to the engineer with some experience in the sphere. He will find in the later sections on design methods and special problems a more extensive and practical approach than is available elsewhere.

C. H. BRAYBROOK

## SERVOMECHANISMS

P. L. TAYLOR

LONGMANS. 1960. 418 PP. £2 2S.

FOR years the serious student of closed-loop systems has been compelled to buy a number of works to cover his subject. In this one the author has gathered together the essential information in a logical manner. No lecturer concerned with teaching the topic can afford to miss this text.

Its three parts are intended for three successive years of study and deal first with background, then with the components and techniques used, and finally with the methods of analysis and design. In this way the student is not overburdened with advanced mathematics before he has met it elsewhere and before he sees its purpose. This arrangement also has the advantage that the notation can be consistent throughout, and examples with a practical flavour can be used at all stages. Suitable comments indicate when rigid mathematical methods are not used, and these help the student who likes to get his theory clear.

A few omissions are inevitable in this broad sphere, and these are covered by suitable references to other volumes. The book ends with an example of design worked out in detail and a few useful appendixes.

A. ASBURY

## THE SWEDISH 380KV SYSTEM

STOCKHOLM: SWEDISH STATE POWER BOARD. 1960. 352 PP. 30 SW.CR.

THE construction in Sweden of the first 380kV transmission line in the world and the subsequent development of the associated system have been described and discussed in many conferences and publications during the past few years, and supply engineers everywhere will welcome this book.

No greater claim is made for it than that, in response to widespread interest, it assembles some of the numerous technical articles which have appeared from time to time. The pages traverse, in a pleasantly objective manner, the whole process of visualizing the expanding need for power, examining and testing the characteristics of various transmission arrangements, building the selected system as economically as possible, and observing carefully all the operating results with a view to the introduction of such changes as seem to be justified.

Examination of system stability, the application of the series capacitor, the testing of circuit-breakers and the development of overhead-line structures are subjects of most interesting accounts; and certain broader issues, such as supply-system organization, interconnection with adjacent countries, and international liaison, are amply treated. Many will possibly find it a disappointing anticlimax that the plans for the future envisage no greatly increased transmission voltages in Sweden.

*Insulator test on a 'hot' line in Sweden*

Delegates to C.I.G.R.É. and visitors to Sweden will be happily reminded of many friendly personalities and frank discussions, and those who are concerned with high-voltage power transmission will value the work as a source of reference—although, unfortunately, there is no index. All engineers will recognize and approve the principle evident in this collection of papers: that, while each country must solve its own power problems in accordance with its own particular circumstances, the free pooling and discussion of technical information represent, to use Mr. G. Jancke's phrase, 'an indispensable condition for future technical developments'.

The standard of English usage is excellent and certainly

as good as would be obtained from any similar group of British engineers. There is, inevitably, some repetition of basic system data; and it is unfortunate that, in so welcome and well presented a volume, there are so many minor printing errors.

F. J. LANE

## INTRODUCTION TO CONGESTION THEORY IN TELEPHONE SYSTEMS

R. SYSKI

OLIVER AND BOYD. 1960. 742 PP. £5 5S.

THE application of probability theory to telephone traffic has gradually grown over the last half-century or so, and there have been many papers on the subject. There have, however, been very few books, and Fry's 'Probability and its engineering uses' (1928) has been the only one dealing mathematically with the topic.

Since 1928, a great deal of new work has been done. There have been new fundamental results by theorists such as Feller, and many applications of theory, not only to telephone problems but to problems of essentially the same nature in many other fields. Syski's volume, evidently based on a thorough study of the literature, now presents a new comprehensive treatment which will be invaluable to those interested in the theoretical approach.

The text covers probability theory in general, but concentrates on stochastic processes and telephone traffic as a stochastic process. The practical applications are subdivided in the usual way: loss systems and delay systems; gradings and link systems. Some additional problems, including variations in queue-discipline, are given special study, and there is a chapter on exchanges as a whole and on connection between exchanges. A section giving a technical description of telephone systems has been contributed by N. H. G. Morris. There is a useful mathematical appendix, a list of about 500 references, a name index and a subject index.

Although the author asserts that 'the book is written at a level which should be easily accessible to the practical engineer who likes his mathematics', it will need a fair knowledge of mathematics and a readiness to handle the topic in abstract symbolic terms before it can be assimilated. There are, however, many such engineer-mathematicians, and they will undoubtedly welcome this publication.

W. E. THOMSON

## INTRODUCTION TO MODERN NETWORK SYNTHESIS

M. E. VAN VALKENBURG

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1960. 498 PP. £4 14S.

DESPITE the extensive literature on synthesis, the ideal introduction has yet to be written. In the language of the subject, this book is a good approximation, but far from equal-ripple; it comes close to target over part of the wide spectrum of topics involved, but departs more widely elsewhere.

The best part deals with network realization methods. The general driving-point impedance and the more important special cases for one- and two-terminal pairs—*LC*, *RC*, *RL*, lattice, ladder, and singly and doubly terminated networks—all receive attention. The classical methods of Brune, Cauer, Darlington, Guillemin, Bott and Duffin are described clearly and illustrated by examples; also, the treatment is sufficiently up to date to include, e.g., Kuh's method for doubly terminated *RC* networks published in 1958. There is also a chapter on image-parameter methods, which are still valuable. The most important omissions are networks with active elements, or more than two ports.

The treatment of rational approximation is less comprehensive. It deals adequately with Butterworth and Chebyshev functions and maximally-flat delay. There is nothing about stop-band ripple, time-domain approximation, phase quadrature, or any general procedure except the rather crude break-point method, and only a very cursory account of the potential analogue.

Positive-real functions, basic to realizability conditions, are treated at length but with occasional mathematical looseness which might confuse the thoughtful novice; probably most readers will be either too pragmatic to worry about this, or sufficiently knowledgeable to fill the gaps.

In short, the reader seeking an introduction to the subject will find an extensive and lucid treatment of realization methods, and a less comprehensive, but generally clear, account of other aspects of network synthesis.

K. W. CATTERMOLE

## FUNDAMENTALS OF ELECTRON DEVICES AND CIRCUITS

H. R. WEED and W. L. DAVIS

PITMAN. 1960. 591 PP. £3

THE authors have also published a volume entitled 'Industrial electronic engineering', and their interest in industrial use and practical application is apparent throughout the present work. This deals entirely with low-frequency electronics but nevertheless covers a wide field, discussing in some detail such diverse topics as polyphase rectifiers, transistor circuits, magnetic amplifiers, industrial timing circuits, etc., as well as most of the conventional vacuum-tube devices. The authors set out to produce a publication of interest to electrical and non-electrical engineers alike, and both classes of readers will find the argument well presented and easy to follow.

Some may find the title misleading, however, since the discussion of the *internal* electronics of the devices concerned is entirely qualitative. For instance, the Langmuir–Child law is considered 'rather difficult to derive' and is merely quoted, while at the same time the discussion of Fourier analysis is insufficient to allow any treatment of class C amplification. The 'fundamentals' with which the text is mainly concerned are thus those of the *use* of devices rather than of their pure functioning.

Subject to this qualification, both experienced electrical engineers and students will find this book a practical and up-to-date introduction to the topic. The student will, moreover, derive benefit from the numerous problems included, and all will appreciate the realism which is added by frequent illustration of the discussion by quotations from manufacturers' data.

G. D. SIMS

# LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

## BOOKS

BERANEK, L. L. (*Editor*) 534.83

**Noise reduction;** prepared for a special summer program at the Massachusetts Institute of Technology*

New York and London: McGraw-Hill, 1960. pp. x, 752. 23·5 × 15·5cm. £5 12s. 6d.

This is a practical work dealing with the reduction of noise from home appliances, industrial machinery, vehicles, aircraft, etc.

DRAPER, C. S., and others 629.135

**Inertial guidance***

London and New York: Pergamon Press, 1960. pp. 130. 23 × 15·5cm. £2 2s.

Considers the theoretical and practical problems of guiding vehicles and missiles, with special emphasis on the principles of inertial-guidance systems.

FINN, D. 658.8

**Public relations and management***

New York: Reinhold. London: Chapman and Hall, 1960. pp. xiii, 175. 19 × 13cm. 36s.

Explains what public relations can and cannot do for a company. In many places it is critical of the claims made by public relations officers, and it probes beneath the current clichés which often confuse rather than enlighten the layman. Ethical aspects of public relations are also discussed.

FITCHEN, F. C. 621.314.7

**Transistor circuit analysis and design***

New York and London: Van Nostrand, 1960. pp. xi, 356. 23·5 × 15·5cm. £2 16s.

The early chapters describe biasing currents, amplification factor, impedance, etc. of transistors, and briefly treat semiconductor physics. The remainder of the volume is devoted to design considerations. This book is reviewed on p. 43.

LABOVITCH, C. (*Editor*) 37

**Directory of opportunities for graduates 1960**

London: Cornmarket Press, 1960. pp. 248. 22 × 14cm. 8s. 6d.

Gives brief details of the size, scope, activities and products of a considerable number of organizations, followed by an indication of the types of graduate they require—arts, science or engineering—and the nature of the work, training, locations and salary schemes.

LYNN, G. E., and others 621.318.42

**Self-saturating magnetic amplifiers***

New York and London: McGraw-Hill, 1960. pp. xv, 217. 23·5 × 15·5cm. £3 2s.

The theoretical treatment expressly recognizes the non-linear features of magnetic-amplifier operation. Practical aspects of auto-excited magnetic amplifiers are then described, and two specimen designs are worked out. This book is reviewed on p. 46.

LYTHALL, R. T. 621.316.7

**A.C. motor control and distribution gear***

Glasgow: The University Press, 1960. pp. iv, 95. 22·5 × 14·5cm. 15s.

Considers only equipment of the air-break automatic-contactor type for the control of motors up to 600 volts a.c. It includes standard methods of starting, simple control circuits and sequence-interlocking schemes, protective gear, short-circuit problems related to busbars and apparatus on industrial group motor-control boards, and flame-proof equipment.

MITCHELL, H. G. 537

**A textbook of electricity. 6th M.K.S. edition***

London: Methuen, 1960. pp. x, 598. 20·5 × 13·5cm. 25s.

This is for students taking physics at advanced and scholarship level and for open university scholarship candidates. The M.K.S. system has been introduced in this edition.

SWEDISH STATE POWER BOARD 621.315.027.3

**The Swedish 380 kV system**

Stockholm: Swedish State Power Board, 1960. pp. 352. 24 × 17cm. 41s. 3d.

Presented as the first of a series of volumes describing the work of the Swedish State Power Board, it discusses the problems associated with the development and operation of a transmission system for 380kV, including transformer stations, protection and maintenance. This book is reviewed on p. 46.

SWENNE, C. M. 621.385.38

**Thyratrons***

London: Philips Technical Library, 1960. pp. viii, 73. 21·5 × 15cm. 15s.

Describes the physical principles, characteristics and applications of thyratrons. This book will be reviewed in a future issue.

SYSKI, R. 621.395.34

**Introduction to congestion theory in telephone systems***

London: Oliver and Boyd, 1960. pp. xvi, 742. 25 × 16cm. £5 5s.

Presents the study of stochastic processes, describing the passage of telephone traffic through a switching system, and introduces recent mathematical developments in general congestion theory applicable to telephone traffic. This book is reviewed on p. 47.

TAYLOR, P. L. 621–52

**Servomechanisms;** an introduction to the practice and theory of closed-loop position-control systems, with an account of methods of data transmission and computation*

London: Longmans, 1960. pp. xiv, 418. 25 × 16cm. £2 2s.

The book leads to a fairly rigorous analysis of systems having components with linear properties and introduces mathematical methods for this purpose. It includes worked examples and problems for the student to solve. There is a bibliography of over 80 references. It is reviewed on p. 46.

## OTHER PUBLICATIONS

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH: BUILDING RESEARCH STATION

**Noise in factories** by A. G. Aldersey-Williams. Factory building studies, 6

London: H.M. Stationery Office, 1960. pp. 25. 24·5 × 18cm. 3s. 6d.

INTERNATIONAL TELECOMMUNICATION UNION

**International telecommunication convention, Geneva 1959.** Final protocol to the convention, additional protocols to the convention, resolutions, recommendations and opinion

Geneva: International Telecommunication Union, 1960. pp. 188. 21 × 14·5cm. 8s. 6d.

**Radio regulations, Geneva 1959.** Additional radio regulations, additional protocol, resolutions and recommendations

Geneva: International Telecommunication Union, 1960. pp. 641. 21 × 14·5cm. 31s. 6d. (including appendixes 25 and 26)

**Radio regulations, Geneva 1959. Appendix 25.** Frequency allotment plan for coast radiotelephone stations operating in the exclusive maritime mobile bands between 4000 and 23000kc/s

Geneva: International Telecommunication Union, 1960. pp. 33. 21 × 14·5cm.

**Radio regulations, Geneva 1959. Appendix 26.** Frequency allotment plan for the aeronautical mobile service and related information

Geneva: International Telecommunication Union, 1960. pp. 76. 30 × 21cm.

NATIONAL PHYSICAL LABORATORY

**The refractive index of air for radio waves and microwaves**

Teddington: National Physical Laboratory, March 1960. pp. 27. 24·5 × 15cm. n.p.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

**13th survey of electric power equipment;** situation and prospects as at 1st January 1960

Paris: Organisation for European Economic Co-operation, 1960. pp. 132. 27 × 21cm. 10s.

## Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card, which is available on request from the Secretary of The Institution

**January 1961**

S **18** *Wednesday* M. N. JOHN, B.SC. 'A general method of digital network analysis particularly suitable for use with low-speed computers' (paper 3259s) *synopsis:* May 1960; P. P. GUPTA, PH.D., B.SC., *and* PROF. M. W. HUMPHREY DAVIES, M.SC. 'Digital computers in power-system analysis' (paper 3484s) *synopsis:* December 1960

ED **20** *Friday* G. S. C. LUCAS, O.B.E., F.C.G.I., will open a discussion on 'Management studies for junior engineers'* (at 6 p.m., tea at 5.30 p.m.)

M **24** *Tuesday* E. H. FROST-SMITH, B.A., PH.D., will open a discussion on 'Machine-tool control'†

E **25** *Wednesday* W. E. WILLSHAW, M.B.E., M.SC.TECH. Lecture on 'Generation and amplification in the millimetre-wave field'†

**February 1961**

S **1** *Wednesday* A. E. GUILE, PH.D., B.SC.(ENG.) 'The protection of high-voltage insulators from power-arc damage' (paper 3289s) *synopsis:* July 1960

O **2** *Thursday* A. J. BLUNDELL, A. E. GARSIDE, B.SC.(ENG.), R. G. HIBBERD, B.SC., *and* I. WILLIAMS, B.SC. 'Silicon power rectifiers' (paper 3362U) *synopsis:* November 1960

MED **3** *Friday* Discussion on 'Recent developments in eye recording' (at 6 p.m., tea at 5.30 p.m.)

M **7** *Tuesday* E. M. BRADLEY. Lecture on 'Magnetic properties of thin films for computing devices'†

EM **8** *Wednesday* Joint Dinner-Dance (at the Café Royal, London, at 7 for 7.30 p.m.)

U **9** *Thursday* E. R. RADWAY 'Some notes on the electrical requirements of general cargo docks' (paper 3365U) *synopsis:* December 1960

I **13** *Monday* A. H. MUMFORD, O.B.E., B.SC.(ENG.), *and* D. S. ROLFE will open a discussion on 'The road to Corporate membership: What is the responsible experience required?'* (Joint Meeting with the London Graduate and Student Section at 6 p.m., tea at 5.30 p.m.)

ED **14** *Tuesday* F. T. CHAPMAN, C.B.E., D.SC.(ENG.), B.SC., will open a discussion on 'Technical teacher training'* (at 6 p.m., tea at 5.30 p.m.)

S **15** *Wednesday* D. RUDD, B.SC.(ENG.) 'A general theory of depreciation of engineering plant' (paper 3366s) *synopsis:* November 1960

**16** *Thursday* L. J. DAVIES, M.A., B.SC. The Faraday Lecture. 'Transistors and all that' (at Central Hall, Westminster, London S.W.1, at 6 p.m.; admission by ticket available from the Secretary of The Institution on receipt by him of a stamped addressed envelope) (see December 1960 *Journal*, p. 740, for synopsis)

E **17** *Friday* W. B. THOMPSON, B.A., M.A., PH.D. Lecture on 'A comprehensive introduction to plasma physics'†

MSU **21** *Tuesday* E. KUFFEL, M.SC., PH.D. Lecture on 'Sphere-gaps'† supported by the following papers: E. KUFFEL, M.SC., PH.D. 'Influence of humidity on the breakdown voltage of sphere-gaps and uniform-field gaps' (paper 3322M), 'The direct voltage calibration of air-gaps in a uniform field and between spheres up to 25cm in diameter, with recommendations for standard test conditions' (paper 3372M), and 'The effect of irradiation on the breakdown voltage of sphere-gaps in air under direct and alternating voltages' (monograph 329M; *synopsis* February 1959); E. KUFFEL, M.SC., PH.D., *and* A. S. HUSBANDS 'The influence of nearby earthed objects and of the polarity of voltage on the direct voltage breakdown of horizontal sphere-gaps' (paper 3371M) (Joint Meeting)

E **22** *Wednesday* J. MEGGITT, M.A., PH.D. Lecture on 'Coding theory and its applications'†

**23** *Thursday* Annual Dinner (at Grosvenor House, Park Lane, London W.1, at 7 for 7.30 p.m.)

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance

## District Meeting

ARRANGEMENTS for a District Meeting in February 1961 other than in the area of a local Centre

**February 1961**

OXFORD (at the District Office of the Southern Electricity Board, 37 George Street, at 7 p.m.)

**8** *Wednesday* M. J. L. PULLING, C.B.E., M.A. 'Development of Eurovision'

## *INQUIRY INTO HIGHER EDUCATION*

THE Government have established a committee to review the pattern of full-time higher education in Great Britain and, in the light of national needs and resources, to advise on what principles its long-term development should be based. In answer to a question in the House of Commons, the Prime Minister stated that the committee would recommend possible changes in the pattern, new types of institution, and modifications in the present arrangements for planning and co-ordinating the development of the various types of institution.

The committee, whose chairman is to be Lord Robbins, are expected to sit for two or three years, at the end of which their report is to be published. The appointment of the committee will not hold up action on issues such as university expansion which are currently before the Government.

# Elections and transfers

*The following elections and transfers approved by the Council of The Institution are effective from the 1st December 1960*

## ELECTIONS

### *Associate Members*

DEHN, Rudolf, M.SC.
ECKBO, John Spargo, B.SC.(ENG.)
LEECE, Ronald
ROGAN, John
SCOTT, Walter, B.SC.

### *Associates*

FIELDING, George Edward
GRAY, George William
JEFFERY, Eric George Hider
WATKINS, Eric Isaac John
WILLIAMS, John Lewis

## TRANSFERS

### *Associate Member to Member*

DESHPANDE, Datta Laxman, B.SC., M.SC.(ENG.)
FLETCHER, Ralph Owen, B.SC.
GAYMER, John Edward Ivens, D.F.H.
HINTON, William Robert
JOHNSON, Peter Harry James
MAINER, Oswald Edwin, M.SC.TECH.
STENNING, Luis Charles, B.SC.
STOCKELL, Cyril John, B.SC.(ENG.)
SUMMERLIN, Frederick Arthur, M.SC.

### *Associate to Associate Member*

ANAND, Vidya Bhushan, B.A., M.SC.

### *Graduate to Associate Member*

ARNOLDT, Peter, B.E.E.
BELLAMY, Ronald Samuel
BLAGDON, Gordon George Eric
BRADSHAW, George, B.SC.
BURFORD, Howard Charles, B.SC.
CHARLES, Brian Victor William
CLYNE, John Peter, M.A.
COLEMAN, Kenneth John, B.SC.(ENG.)
COOKE, Dennis Howard
CORNFORTH, Kenneth John, B.SC.(ENG.)
DAVIES, Edward Gordon
DELGADO, Crisanto, B.SC.(ENG.)
DENHAM, John Alexander, B.SC.(ENG.)
DYSON, Ernest Darwent, M.A.
FLUDE, Benjamin Ernest
GALLAGHER, John Francis
GARWOOD, William Havers, B.SC.(ENG.)
HAMMOND, Herbert Henry
HASHEM, Abdullah Ibrahim, B.SC.(ENG.)
HOLE, Bernard Gerard
HOLLAND, Edward
IRVINE, Alastair Munro, B.SC.(ENG.)
KEERS, Royce
KIRK, Leonard Freeman
KOSHAL, Jagan Nath
LEICESTER, William Lancelot
MACBRIDE, John Millar Robertson
PHILLIPS, Alan James Horton
POCKETT, Albert Dan
PRIEST, Charles John, B.SC.(ENG.)
PUDSEY, David Graham, B.SC.
RAMABHADRAN, Srinivasa, M.A.
SIMSON, Robert Edward, B.SC.(ENG.)
THURNELL, Duncan Philip, B.SC.(ENG.)

*The following elections and transfers approved by the Council of The Institution are effective from the 1st December 1960*

## ELECTIONS: 1st LIST

### *Graduates*

AGARWAL, Gopal Krishna, B.SC., B.SC.(ENG.)
BRAITHWAITE, Hugh Beaty, B.SC.
BROWN, Herbert Moorcroft, B.SC.
DAY, Maurice John
DEAN, David Christopher, D.F.H.
ELLIOTT, Ronald
GIMSON, Alan Geoffrey, B.SC.
JONES, Arthur Brian, B.SC.
LOVETT, Noel William
LYNCH, George Edward, B.ENG.
MARTIN, Peter David, B.SC.(ENG.)
MONRO, Peter David, B.E.
NORTON, Brian Victor
PALTRIDGE, Henry, B.E.
PIGGOTT, Raymond Sidney
RACKIND, Malcolm Ivor, B.SC.
SAMPSON, Harold Davis
SHELEF, Zvi, M.SC.(ENG.)
SHETH, Vikram Ramanbhai, B.SC.
SOMMERVILLE, James Gibb, A.R.C.S.T.
STARK, Gordon, A.R.C.S.T.
STEWARDSON, Horace Rodney
SUMMERS, James Michael
TSIANG, Chong Loh, B.SC.TECH.
WEBB, Frank William
WILLIAMS, Kenneth

### *Students*

ADAMS, Elfed Cynlais
ANDREW, Ian Charles
AVORY, Peter John, B.SC.
BARKER, Peter Gordon
BARRETT, Michael John
BARTON, John Ross
BASSETT, Richard
BLIGHT, Barry Malcolm
BOOTH, Alan Edward
BOWEN, Stanley Simpson, B.SC.
BRICE, Denzil
BRIDLE, John Elmer
BUDD, Leslie William
BULPETT, Maj. Edward
BURCH, Robert Keith
BUTCHER, Peter
CARNEY, Peter
CHAN, Peng Kong
CLARK, Humphrey Graham
CORSIE, Hugh Alexander
CRABB, David Iain Charles
CULLYER, William John

### *Students* (continued)

DALTON, Michael James
DAVISON, Edward Anthony
DE ZOYSA, Merrenna Colwin, B.SC.
DEWACHI, Abdul
DUNSTAN, Edward John
EAVIS, Frank
EDMONDSON, George Ivan
ELLIS, Peter Brian
FITZGERALD, Sheila
FLACK, Kenneth
FLETCHER, John Herbert
FOSTER, Anthony James
FOSTER, George
FRANKLIN, Karl Peter
GARDNER, Anthony John, B.SC.
GEDDES, William Robert Taylor
GIBSON, Paul Edward
GILLIS, Robert Wilfred
HAJI, Abdeali Taiyebali
HANCOX, David Ian Pascoe
HARRISON, Cedric
HART, Stuart John
HARVERSON, David William
HAWWA, Munir, B.E.E.
HENSON, Peter
HILLIS, Kenneth
HIND, Harold
HOLMES, Raymond
HOOD, Ronald John
HOPE, Charles Louis
HOPKINS, Peter Donald
HOSKING, Keith James Bert
HOSKING, Richard Iain Graham, B.SC.
HOWARD, Roger David
HUGHES, Michael John, B.A.
JATEGAONKAR, Sudhir Narayan
JEFFERIES, Quentin
JENKINS, Windsor
KAPADIA, Taher Abdeali
KEMP, Stanley Colin
KITCHENER, John Wesley
KWOK, Kee Kuan
LALCHAND, Gulabrai
LEE, Brian
LEFTLEY, Barrie
LEWIS, Harry Roy Wynne
LIM, Ching Hwa
LONG, Michael James
LONGTON, Brian
LOTAY, Nirmal Singh
MARK, Robert William
MARRIOTT, Allan Charles
MARTIN, Bruce John
MAYLING, Peter Holland
METCALFE, Ian Richard David
MICKLEBURGH, David Robert
MOHLEJI, Satish Chandra
MOODY, John
MUKHERJEE, Bimal Kumar, B.E.
NEEMS, Paul Henry
NEILSON, Cyril Joseph Patrick
PATEL, Ramanbhai Girdharbhai
PEREIRA, George Aloysius
PHADKE, Shashikant Narayan, B.E.
PHILLIPSON, John Tobin
POWNER, John Henry
PRASAD, Chandreshwar
RAE, Albert
ROBERTSON, David James
ROBERTSON, Michael Alan
ROHRER, Brian Richie
SAHA, Tarak Nath, B.E.E.
SALDER, Danford Henry William
SHARP, Hamish Allan
SHELLEY, David John
SHORROCK, John Anthony
SMITH, Anthony
SMITH, Peter Henry
SMITH-GOOSE, Brian Arthur
SONEJI, Kanayo Tolaram
SPENCER, John Richard
STEVENTON, Brian James
STUART, Malcolm
SUTTON, Graham William
SWAMY, Narayan Gopal, B.E.
TAYLOR, John Livesey
TAYLOR, Michael Lough
THORPE, Anthony Bernard
VIG, Baldev Raj, B.SC.
WALLEN, Oswald George Melmoth
WATSON, Peter Stanley
WATSON, William John Alan
WHITFIELD, Robert Stephen
WHITTEN, Dennis John
WILKINSON, Terence Revell
WILLACY, Douglas James
WILLCOX, Douglas Arthur
WOODHEAD, Peter
WRIGHT, Stephen John
WRIGHT, William Raymond

## TRANSFERS: 1st LIST

### *Student to Graduate*

AYIKU, Moses Nee Buernor
BENSTED Christopher John Philip, B.SC.
BODY, David Henry John
BOYES, Grahame Arthur, B.A.
BRACE, John Lawrence
BRADLEY, Ian Victor Wesley, B.SC.
BURCOMBE, John Edward, B.SC.(ENG.)
BURTON, Clifford John, B.SC.(ENG.)
CHARLES, Emmanuel Kofi, B.SC.(ENG.)
CHUNG-YAN, Glenroy, B.SC.
COLE, David Benjamin
COLPUS, John Russell, B.SC.(ENG.)
COPLEY, Douglas Henry, B.SC.
CUNIIFFE, Neil Hollinrake, B.SC.
DE SOUZA, Harold, B.SC.(ENG.)
DEVENISH, Neville George, B.SC.
FERGUSON, Tony
FREE, John Marshall, B.SC.(ENG.)
GIBSON, Allan Nicholas, B.SC.
HARROLD, Stephen Oliver, B.SC.(ENG.)
HERRING, Gordon
JOHNSTON-SMITH, Christopher Barry, B.SC.(ENG.)
KINSMAN, John Harvey, B.SC.
LAUDER, George, A.H.-W.C.
LESLIE, Ian Stewart, B.SC.
LEVIN, Eliot Bernard, B.SC.(ENG.)
LOWRY, Peter Charles, B.ENG.
MARSHALL, Peter Brian, B.SC.(ENG.)
MATHANAGOPALAN, Nallatamby
MENSAH, Samuel Kwasi, B.SC.(ENG.)
MIDDLETON, Peter Alan, B.SC.(ENG.)
MORRIS, William Arthur, B.SC.(ENG.)
OSBORNE, Peter David, B.SC.(ENG.)
PARKER, Timothy John Kingston, B.SC.(ENG.)
PATEL, Jayantilal Purshottam, B.E.
PIROOZ, Jamshid, B.SC.TECH.
REYNOLDS, Anthony James, B.SC.
SELBY, James Irwin, B.SC.(ENG.)
WRIGHT, Bryan Peter, B.SC.

## ELECTIONS: 2nd LIST

### *Graduates*

BILLAM, Clifford Brayley
BROOKES, Desmond
BUTLIN, John Edmund
CHAN, Sow Chee
COTTON, James Hornby
D'ANDREA, Mario Gerald Rosario, B.SC.(ENG.)
DE, Sankari Prasad, B.SC.
DORRAT, James Ian, B.SC.
FARRELL, John
GEORGE, Roland Arthur
HIGGINS, John Christopher, M.A., M.SC.
HOLMES, Ronald
LEES, Norman, B.A.
MANUEL, Wilfred Henry
MARWICK, David Baikie
POLKINGHORNE, Alan, B.SC.
RICHARDSON, David John, B.SC.
TSAPPI, Philip, B.SC.(ENG.)
WESTON, Peter, B.SC.

*Students*

ALLARDICE, Neil Robertson
ANDERSON, John Wallace
ASHWORTH, Neville Dootson
BALL, Brian
BAYLIS, David Alfred
BECKETT, Susan Flora
BEENHAM, Christopher Alan
BERTRAM, William Barrie
BINES, John Christopher
BLAIR, John Jamieson
BLAKEY, John Michael
BLOODWORTH, David Sydney Snow
BONGIOVANNI, Saviour Victor
BRENNAND, Terence
BROOKS, Robert Stanley
BUCKLAND, David Albert
BURROWS, Darryl Benfield
BURTON, Anthony Brian
BURTON, Peter William
CARMAN, Roger Eric
CARPENTER, Brian Robert
CHAN, Chung Kong
CHAPMAN, Brian Frank
CHILVERS, Richard William
CHIN, Theodore Randolph
CLARKSON, Dale Michael
COOPER, Allen Frederick
COPE, Ian David
COWAN, Graham
CRAWFORD, Brian Thomas
CUNDY, Cyril John
DATTA, Dilip, B.E.E.
DAVIS, Patrick John
DE, Sarat Chandra, B.SC.
DEADMAN, Derek John
DEARNLEY, Ernest Malcolm
DENTON, James
DUBEY, Vishnu Deo
DUFFUS, John Irons
DUKE, David Brian
DURAY, Rajasundram Raja
DYER, Brian Arthur
ECONOMIDES, Agis Achilles
EDWARDS, David Bruce
EMBLETON, Peter Graham
FAIRBANK, Richard
FERGUS, Peter John Brian
FIELD, John David
FORREST, Kenneth Reginald
FOX, Pietro
FROST, Barry Frank
GALLOIS, Avon Paul
GILBERT, Joseph Walter
GINGER, Peter Richard Maclean
GOTT, Brian Ernest Baxter
GRAHAM, Charles Greville
GRAYER, Iain William
GRIFFITHS, David Ernest Charles, B.SC.
GRIFFITHS, Gareth Morris
GRINDLE, Anthony Frank
GUPTA, Lt. Virendra Kumar, I.N.
HANNA, Robert Noel
HARDING, John Joseph Barry
HARGREAVES, Gordon
HARTLEY, Adrian Frank Ridgard
HAYLOCK, John Leonard
HEALE, Bryan David
HERMON, David William
HEYWORTH, Joseph Keith
HILL, Adrian Neville
HINKINS, Peter John
HOWARD, George Reginald
HUGGINS, Barry Spencer
HUMPHREY, John Michael
HUNKING, Charles Roy
HUTCHINGS, Brian William
IEVERS, John Eyre
ISGAR, Christopher Roy
JEFFREY, John Peter
JESSOP, Allen
JOHANNESSEN, Rolf
JOHNSON, Anthony Charles Robert
JONES, Ronald Allan
KEENAN, Thomas James
KENNEDY, Maurice Forsythe
KHALIFEH, Mohamed Fareed
KHOO, Thiam Hee
LANE, Geoffrey
LITTLE, William James, B.SC.
LOGAN, John
MCCOWAN, Douglas
MACDONALD, Alisdair David
MACKINTOSH, Robert Ian Lewellyn
MALLAPUR, Suresh Shripad
MARAR, Nail George
MARQUIS, David Gordon
MARRIOTT, John Oliver Hayes
MARSTON, Harold
MAY, David Harold
MEAD, John
MIDGLEY, Brian John
MILLIGAN, John
MILNE, Alasdair Birrell
MIRZA, Humayun
MITCHELL, James Kennedy
MORRIS, Ian
MORRIS, Trevor
NAGAHAWATTE, Subadra, B.SC.
NICHOLSON, Rohinton Savakshaw, B.E.
NUTTALL, Brian
ORR, Thomas Quinlan
PACEY, Gordon Cameron
PAL, Govardhan Laxman, B.SC.
PALMER, Adrian
PANCHALINGAM, Vythilingam Cartigesoe, B.SC.
PARDINGTON, Ian
PARKER, Christopher Hedley
PATEL, Prahladray Chhaganlal
PATERSON, Archibald Young
PAYNE, Roger Wedgwood
PEASE, Roger Stephen Arthur
PICKARD, Gordon Wilson
PLAYFORD, Christopher John
PROUDMAN, Michael Charles
PURSLEY, William Charles
RAGGETT, Christopher Roy
RAMACHANDRAN, Komandur Srinivasan, B.SC., B.E.
RANCE, Brian Ernest
READ, Peter George
RICHARDSON, Philip John
ROOK, Paul Edward, B.SC.
ROWE, Dudley Cyril
ROWLANDS, David James
RYDER, David John
SALMON, Bryan Alfred
SARKAR, Guruprasad, B.SC.
SAVILLE, Geoffrey
SCARSBROOK, Brian Leslie
SCOTT, George Reilly
SENIOR, Henry Stanley
SEQUEIRA, Danny Aloysious
SHAH, Vinod Jatashanker
SHAW, James Gordon
SHAW, Thomas Arthur
SHERIDAN, Ralph
SHERTUKDE, Vijay Sitaram
SINGH, Ajai Pal
SINGH, Amrik
SMITH, Alan Peter
SMITH, Donald Geoffrey
SMITH, James
STEVENS, John Bernard
STIMPSON, Ian William
STRANKS, Michael Bradley
SYMONS, John Gilbert
TERRY, John Alan
THOMAS, Charles Peter
THOMPSON, Anthony Arthur
TONG, Kin-Wah
TOOKE, Dudley Jack
TUCKER, Jeremy McIntyre Crutchlow
WALKER, Lionel Robert
WARNE, Alan Frederick
WARRINER, Christopher John
WATTS, Malcolm William
WEIR, Alexander
WHITE, Nicholas Courtenay
WHITWORTH, Rodney
WICKRAMASINGHE, Tissa Banda
WILLIAMS, Derek Edward
WILLIAMS, John Francis
WILLIAMS, Peter Albert
WILSON, Graham
WINNING, David James
WOODROFFE, Daniel Michael
YAP, Tuan Fatt
YATES, Bernard

## TRANSFERS: 2nd LIST

*Student to Graduate*

ANDERSON, David Keith, B.SC.(ENG.)
BOOKER, David, B.SC.(ENG.)
BRAMALL, John Reginald, B.ENG.
BRISTOW, Anthony Lawrence, B.SC.
BURRELL, Geoffrey John, B.SC.
CALLICK, Alan David, B.SC.(ENG.)
COLYER, Ronald Edgar, B.SC.
CONWAY, Alan Charles, B.SC.
CRAWLEY, Kevin John, B.SC.(ENG.)
CREE, Ronald George, B.SC.
CROFTS, John William, B.SC.(ENG.)
ESTLIN, Boyd Warren, D.F.H.
EVANS, Donald Edward, A.R.C.S.T.
EVANS, Graham Lindsay, B.SC.(ENG.)
FEKETE, John Paul, B.SC.
FORSTER, Brian Michael, B.ENG.
GANDERTON, William
GHEST, Robert Clive, B.SC.
GOLLOP, Roger Warner, B.SC.(ENG.)
LAST, Brian Patrick, B.SC.(ENG.)
LYNN, Paul Antony, B.SC.
NAIK, Atul Mahadev
RYDING, John, B.SC.(ENG.)
WHITELAW, Michael John, B.SC.

## British Nuclear Energy Conference

DETAILS of three forthcoming meetings of the British Nuclear Energy Conference are given below. Papers and discussions on the applications of nuclear energy and ancillary subjects are published in the quarterly *Journal of the British Nuclear Energy Conference*. The annual subscription payable by members of The Institution who wish to receive the quarterly regularly is 30s. post-free. Single copies are available at 7s. 6d. each

**1961**

**JANUARY 24** *Tuesday* (7.30 p.m.)

*Sponsoring society:* Institution of Chemical Engineers
*Place of meeting:* Birkenhead Technical College, Lancashire

EXPERIMENTATION AND REACTOR DESIGN IN PROCESS RESEARCH AND DEVELOPMENT W. Waddington and W. D. Betts

**FEBRUARY 15** *Wednesday* (2.30 p.m.)

*Sponsoring society:* Institute of Fuel
*Place of meeting:* Royal Victoria Hotel, Sheffield

CURRENT DEVELOPMENTS IN NUCLEAR POWER PLANT W. R. Wooton

**FEBRUARY 22** *Wednesday* (6 p.m.)

*Sponsoring society and place of meeting:* Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

Thomas Hawksley Lecture on PROSPECTS OF FUSION POWER
Prof. P. M. S. Blackett

**FEBRUARY 28** *Tuesday* (5.30 p.m.)

*Sponsoring society:* Joint Panel on Nuclear Marine Propulsion
*Place of meeting:* Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London E.C.3

SAFETY OF NUCLEAR MARINE PROPULSION PLANT J. M. Murray and H. N. Pemberton

## Automatic telex

THE automatic telex exchange in the new Fleet Building, Farringdon Street, London, was opened on the 12th December 1960. It will make the inland telex service in Britain completely automatic, and it will be possible for all telex calls between subscribers in the United Kingdom to be completed by dialling.

Twenty exchanges have been installed to make the service automatic. They use electro-mechanical switching principles similar to those of telephone exchanges, although the telex system is completely separate from the telephone system. However, full use is made of the telephone-cable network for routing telex circuits. Multi-channel voice-frequency telegraph systems are used for the inter-exchange trunk circuits and for long subscribers' lines.

The Post Office expect that, by 1980, 40 000 subscribers will be employing the service.

# ANNOUNCEMENTS TO MEMBERS

## THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 9TH DECEMBER 1960

| | *no. of contributors* | £ | *s.* | *d.* |
|---|---|---|---|---|
| £1000 and over | 8 | 8685 | 0 | 0 |
| £100 to <£1000 | 32 | 7181 | 3 | 0 |
| £5 to <£100 | 924 | 9654 | 19 | 7 |
| £2 to <£5 | 2288 | 6315 | 2 | 10 |
| under £2 | 29135 | 15323 | 3 | 2 |
| | | 47159 | 8 | 7 |

## APPOINTMENTS AND NOMINATIONS

JOINT COMMITTEE ON THE APPLICATIONS OF ELECTRICITY IN AIRCRAFT

ON the nomination of the Admiralty, the Council have approved the appointment of Cmdr. P. G. Wigney, R.N., to serve on the above joint committee.

NEWPORT AND MONMOUTHSHIRE COLLEGE OF TECHNOLOGY, ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. W. E. Richardson, MEMBER, as their representative on the above committee.

JOINT COMMITTEE FOR NATIONAL CERTIFICATES AND DIPLOMAS IN ELECTRICAL ENGINEERING FOR ENGLAND AND WALES

The Council have nominated Prof. M. W. Humphrey Davies, M.SC., MEMBER, Dr. J. B. Higham, B.SC., ASSOCIATE MEMBER (to fill a vacancy caused by the retirement of Mr. G. S. C. Lucas, O.B.E., VICE-PRESIDENT), Mr. E. R. L. Lewis, M.A., ASSOCIATE MEMBER, Dr. J. E. Richardson, B.ENG., MEMBER,* and Mr. E. M. Price, M.A., MEMBER, as their representatives on the above committee.

* Jointly by the Minister of Education, on the nomination of the Association of Technical Institutions, the Association of Principals of Technical Institutions and the Association of Teachers in Technical Institutions

JOINT COMMITTEE FOR NATIONAL CERTIFICATES AND DIPLOMAS IN ELECTRICAL ENGINEERING FOR SCOTLAND

The Council have nominated Prof. E. G. Cullwick, O.B.E., M.A., D.SC., MEMBER (to fill a vacancy caused by the death of Prof. B. Hague, D.SC., PH.D., MEMBER), Mr. W. B. Laing, MEMBER, Prof. M. G. Say, PH.D., M.SC., F.R.S.E., MEMBER, and Mr. J. Stewart, M.A., B.SC., ASSOCIATE MEMBER, as their representatives on the above committee.

JOINT COMMITTEE FOR NATIONAL CERTIFICATES AND DIPLOMAS IN ELECTRICAL ENGINEERING FOR NORTHERN IRELAND

The Council have nominated Prof. T. P. Allen, M.SC., MEMBER, Mr. J. R. W. Murland, B.SC.(ENG.), MEMBER, and Mr. T. S. Wylie, MEMBER, as their representatives on the above committee.

ENGINEERING INSTITUTIONS EXAMINATION PART I COMMITTEE

The Council have nominated Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D., MEMBER, Dr. H. L. Haselgrave, M.A., M.SC.(ENG.), MEMBER, and Mr. C. T. Melling, C.B.E., M.SC.TECH., VICE-PRESIDENT (to fill a vacancy caused by the retirement of Mr. A. H. Mumford, O.B.E., B.SC.(ENG.), VICE-PRESIDENT), as their representatives on the above committee.

## PROGRAMME OF MEETINGS

SESSION 1960–61

THE programme card of London meetings for the second half of the 1960–61 Session is being sent with this issue of the *Journal* to all members not residing within the area of a local Centre or Sub-Centre.

Any member living in the Provinces who often visits London and is thus able to attend London meetings may obtain a copy of the London card on application to the Secretary of The Institution.

## MEMBERS TRAVELLING TO AND FROM THE UNITED KINGDOM

MEMBERS visiting or taking up residence in the areas of any of the Oversea Branches, Oversea Committees, Joint Groups or Professional Groups which are listed on pp. 68 and 69 are invited to apply to the Secretary for a letter of introduction to the appropriate Honorary Secretary.

If members coming home from oversea will inform the Secretary of The Institution of their address in this country, even if they do not desire a change of address to be recorded in the Institution Register, arrangements will be made for them to be sent information about the various meetings etc. of The Institution and its local Centres and when occasion arises for them to be put in touch with other members.

The Secretary will be glad if members from oversea who are able to visit the Institution premises will call on him.

## COMMUNICATIONS FROM OVERSEA MEMBERS

OVERSEA members are specially invited to submit for publication in the *Proceedings* written communications on papers read before The Institution or published in the *Proceedings* without being read. The contributor's country of residence will be indicated. Brief articles, items of news and photographs intended for the *Journal* will also be welcome.

Copies of all papers which will be read before The Institution are sent to each Oversea Representative of the Council for distribution to members likely to be in a position to submit communications.

## DECLARATION ON FAIR COPYING OF SCIENTIFIC INFORMATION

THE Institution, in common with more than 70 other scientific and learned societies, has subscribed to the Royal Society's Declaration on Fair Copying, which reads as follows:

'We will regard it as fair dealing for the purpose of private study or research when a non-profit-making organization, such as a library, archives office, museum or information service, owning or handling scientific or technical periodicals published by us makes and delivers a *single* reproduction of a part of an issue thereof to a person or his agent representing in writing that he desires such reproduction in lieu of a loan or manual transcription and that he requires it solely for the purpose of private study, research, criticism or review, and that he undertakes not to sell or reproduce for publication the copy supplied, provided:

1. The recipient of the copy is given notice that he is liable for infringement of copyright by misuse of the copy, and that it is illegal to use the copy for any further reproduction
2. The organization making and furnishing the copy does so without profit to itself
3. Proper acknowledgment is given to the publication from which the copy is made
4. Not more than one copy of any one excerpt shall be furnished to any one person.

'The exemption from liability of the library, archives office, museum or information service herein provided shall extend to every officer, agent or employee of such organization in the making and delivery of such reproduction when acting within the scope of his authority of employment. This exemption for the organization itself carries with it a responsibility to see that employees caution those receiving copies against the misuse of material reproduced.

'We reserve the right to take action against any person or organization copying or misusing for any purpose whatever the whole or part of a work published by us without abiding by the conditions laid down herein unless the person or organization has our special permission in respect of the item to be copied.

'We reserve the right to withdraw this declaration.'

## SCIENCE MUSEUM LIBRARY: PHOTOPRINT SERVICE

UNDER the terms of the Royal Society's Declaration on Fair Copying (see above) and the Copyright Act 1956, the Science Museum Library is permitted to supply photoprints of articles from many of the periodicals it holds. The charge is 5s. for each article requiring not more than five photographs (a maximum of 10 consecutive pages). Longer articles cost 5s. for each 10 pages or fraction thereof.

A member of The Institution who requires a photoprint of material appearing in a technical periodical should inform the Librarian of The Institution and should supply as many bibliographical details as possible. These will be verified, and the appropriate requisition forms bearing an undertaking with regard to copyright will be forwarded to the member for signature. The signed forms should then be sent direct to the Science Library (Photocopy), Science Museum, South Kensington, London S.W.7.

No remittance should be sent until an invoice has been received from The Institution.

Members may like to be reminded that reprints of many recent papers published in the *Proceedings* are available on request from the Secretary of The Institution at a price of 2s. per reprint (see p. 38).

## PAUL INSTRUMENT FUND

THE Royal Society Committee administering the Paul Instrument Fund invite applications for grants for the design, construction and maintenance of new or much improved types of physical instruments and apparatus for investigations in pure and applied physical science, particularly where a relatively large expenditure may be justified on experimental apparatus. Grants can be made for or towards the provision of equipment, building facilities or financial or other aid in such manner as the Committee may determine.

The Committee will decide the ultimate destination and ownership of all instruments and apparatus produced by means of grants from the Fund. Any invention or improvement in existing inventions made by a grantee must be communicated forthwith to the Committee, and no grantee may apply for or obtain patent rights for such invention without the sanction in writing of the Committee.

Since its inception in 1943, the Committee have voted nearly £165000 in respect of some 42 instruments. Since 1954, projects for which grants have been made have included a new type of Wilson cloud chamber, the design of solid-state image intensifiers, a static scanning fibroscope, an ultrasonic image camera, and power measurement at microwave frequencies.

Applications may be submitted by any individual or group engaged in research in Great Britain. Applicants must be British subjects. Further particulars and application forms are obtainable from the Assistant Secretary, The Royal Society, Burlington House, London W.1.

## RAILWAY MODERNIZATION CONFERENCE

A RAILWAY Modernization Conference will be held at The Institution of Civil Engineers, Great George Street, London S.W.1, on the 3rd and 4th May 1961. It is being arranged jointly by The Institution of Civil Engineers, The Institution of Mechanical Engineers and The Institution of Electrical Engineers. Five papers covering the civil, mechanical and electrical engineering aspects of the British Railways modernization plan will be presented for discussion.

Further details will be announced in due course.

## AUTOMATION—MEN AND MONEY

A CONFERENCE on 'Automation—men and money' will be held at Harrogate from the 27th to 30th June 1961 under the aegis of the British Conference on Automation and Computation. This first British conference on the social and economic effects of automation will comprise sessions on economic aspects internal to the firm; economic aspects in the wider context; social aspects internal to the firm; and social aspects in the wider context.

Further information may be obtained from the Conference Secretary, c/o the British Institute of Management, 80 Fetter Lane, London E.C.4.

## INTEGRATED DATA PROCESSING

A ONE-DAY conference on integrated data processing in Britain and America will take place on the 16th February 1961 at the Connaught Rooms, Great Queen Street, London W.C.2. It is being arranged by the British Productivity Council in co-operation with the British Conference on Automation and Computation, the British Institute of Management, and the Institute of Cost and Works Accountants. The conference will begin at 9.45 a.m. and end at 5.10 p.m.

Further information may be obtained from the British Productivity Council (IDP Conference), 21 Tothill Street, London S.W.1.

## LARGE-SCALE INDUSTRIAL VACUUM PLANT

A SYMPOSIUM on user experience of large-scale industrial vacuum plant, arranged by The Institution of Mechanical Engineers and sponsored by the Joint British Committee for Vacuum Science and Technology, will be held at 1 Birdcage Walk, London S.W.1, on the 1st and 2nd March 1961.

The main objective of the symposium is to bring together designers and users of vacuum plant to discuss their problems and techniques. The programme opens on the 1st March at 4 p.m. with a review paper, followed by a group of papers on vacuum processing and treatment of metals. On the 2nd March there will be further papers on metallurgical subjects, together with a contribution on steam ejection vacuum plant and a paper on capacitor drying. The 2nd March will be devoted to a group of papers on medical and food-processing aspects.

Registration forms and further information are available from the Secretary of The Institution of Mechanical Engineers.

## RUBBER AND PLASTICS IN CABLES

A CONFERENCE on rubber and plastics in cables will be held by the Plastics Institute and the Institution of the Rubber Industry at Savoy Place on the 1st March 1961.

Registration forms and further information are available from the Secretary, Plastics Institute, 6 Mandeville Place, London W.1.

## FILM IN SCIENTIFIC RESEARCH

A WORKING party has been set up by the Department of Scientific and Industrial Research to consider British needs in the field of scientific film, with particular reference to the use of film as a research tool and in communicating research results. With a view to helping the working party, a questionary is being circulated to industry, universities, and research organizations. In this way it is hoped to reach all those engaged in the serious use of film for these purposes; who hold stocks of interesting research film or who have developed unusual techniques and applications.

Persons who can contribute to this inquiry but have not received the questionary are invited to get in touch with the Information Division, Department of Scientific and Industrial Research, 14–18 Cornwall Terrace, London N.W.1.

## SPECIAL COURSES IN HIGHER TECHNOLOGY

THE bulletin of special courses in higher technology in London and the Home Counties, covering the spring and summer terms 1961, has been issued by the London and Home Counties Regional Advisory Council for Technological Education.

Copies of the bulletin may be obtained from the Secretary of the Regional Advisory Council, Tavistock House, South Tavistock Square, London W.C.1, price 3s. 6d.

## INTERNATIONAL PRIZE

THE Administrative Council of the Association des Ingénieurs de la Faculté Polytechnique de Mons have decided to establish an international prize of 50000 Belgian francs, which will be awarded every five years, and for the first time in 1965, to the author of the best original work dealing with the art of engineering. Candidates, of any nationality, should be graduates in engineering of universities or institutions of university level.

Works submitted for consideration must be in the French, Dutch, English or German language. Four copies of the typed manuscript are required, and the work should be signed with a pseudonym and addressed to the President of the Association, 9 rue de Houdain, Mons, Belgium. The winning paper will be published in the Bulletin of the Association.

## INSTITUTE OF ENGINEERS, PAKISTAN

THE seventh Annual General Meeting and Convention of the Institute of Engineers, Pakistan, will be held at Dacca, East Pakistan, at the end of February and the beginning of March 1961. The President of Pakistan will inaugurate the function, and the convention will conclude with a study tour of engineering projects in East Pakistan.

Members of The Institution resident in or visiting Pakistan at the time are cordially invited by the Council of the Institute of Engineers, Pakistan, to attend the convention under terms and conditions similar to those applicable to the members of the Institute.

## TRANSMISSION AND PROCESSING OF INFORMATION

AN international symposium on the transmission and processing of information will be held at the Massachusetts Institute of Technology from the 6th to 8th September 1961. The symposium is being organized by the Professional Group on Information Theory of the Institute of Radio Engineers, in co-operation with the Center of Communication Sciences, Research Laboratory of Electronics, M.I.T.

The symposium will present significant new research contributions, either theoretical or experimental, and the programme is being planned specifically for active specialists in the field.

Further information may be obtained from the Chairman of the Organizing Committee, R. M. Fano, R.L.E., M.I.T., Cambridge 39, Mass., U.S.A.

# ADVANCING KNOWLEDGE OF THE IONOSPHERE

A LECTURE entitled 'The ionosphere—a review of recent progress' was delivered by Prof. W. J. G. Beynon before the Section on the 2nd November 1960 at Savoy Place. Mr. J. A. Ratcliffe was in the chair.

This was one of those occasions when the Section allows itself the indulgence of enjoying a purely scientific interlude. Prof. Beynon, who has long had an international reputation for his research on the ionosphere, presented a review of recent progress in this field, much of which has stemmed from studies undertaken during the International Geophysical Year.

### New tools for investigation

For some 30 years, investigations of the ionosphere were largely confined to those which could be made with ground-based equipment. The extension of the network of vertical sounding stations during the I.G.Y., especially in polar and equatorial latitudes, permitted new and detailed studies of ionospheric disturbances and anomalies. However, the advent of space vehicles has now presented the upper-atmospheric physicist with powerful new tools for the investigation of phenomena occurring right through the ionosphere to well beyond the region of maximum ionization in the $F_2$-layer—phenomena which are profoundly influenced by solar disturbances and solar-particle radiation.

After discussing electron density-height profiles and the anomalous behaviour of the $F_2$-layer, Prof. Beynon described the information concerning the D-layer derived from experiments using rockets.

He further showed how measurements with rockets and satellites are leading to a more complete knowledge of the variation of electron density with height than it has been possible to obtain by the usual vertical-incidence sounding method: this latter procedure yields no information below the E-region and above the maximum of the $F_2$-layer—though in recent developments in the United States, in which high-power v.h.f. and u.h.f. transmissions are used, it has been shown by Bowles how to derive the electron density/height profile throughout most of the ionosphere from observations of incoherent scattering from the electrons.

The lecturer also mentioned the use of radar echoes from the Moon for the investigation of the electron content along a path through the entire ionosphere.

Other topics touched on by Prof. Beynon were the correlation of the $F_2$-ionization characteristics with the Earth's magnetic field, and the properties of the ionosphere at high latitudes—particularly in relation to disturbances in the Arctic and Antarctic regions, including polar blackouts and sporadic E-ionization effects. In stressing the potentialities of methods of exploration of the upper atmosphere using space vehicles, he instanced the discovery of the Van Allen radiation belts as an example of what could be achieved; and he concluded his lecture with a description of artificial geophysical effects produced by atomic explosions at appropriate heights in the atmosphere, as in the Argus experiments.

### Faraday as a patron saint

In opening the general discussion, Mr. Ratcliffe commented on the interesting fact that, although the study of the ionosphere was some 35 years old, some really important advances had been made in the last five years. He said that the incidence of the I.G.Y. was not the only cause of this. Past ideas had been too much dominated by the concept of well defined layers, but the new techniques of investigation, and new thoughts about the formation of the $F_2$-layer, had revealed that this was a great oversimplification of the actual state of affairs.

Dr. B. H. Briggs referred to conflicting evidence concerning what occurred above the maximum of the $F_2$-layer at times of magnetic storms, and pointed out that a redistribution of ionization did not necessarily happen as has hitherto been supposed. Some of the interesting phenomena occurring at high latitudes were described by Mr. W. R. Piggott, particularly those arising from the entry into the atmosphere of streams of charged particles.

A practical note was injected into the discussion by Mr. G. Millington, who wanted to know how the new knowledge would assist engineers to plan their communications. Why were maximum usable frequencies greater than simple theory predicted, and what was the best method of calculating field strengths over long paths?

In his reply to the comments made by the various speakers, Prof. Beynon said that if he had had time he would have mentioned the important work of Messrs. A. F. Wilkins and F. Kift in the field of practical applications; it had to be admitted, however, that the calculation of field strengths was still rather uncertain, largely because of our incomplete knowledge of the D-layer—the one nearest to us! Concerning the interrelation of ionospheric and magnetic effects, the question still remains as to which causes which.

In proposing a vote of thanks to Prof. Beynon for his most interesting and comprehensive lecture, Mr. Ratcliffe said that he thought no one would seriously raise the question of the usefulness of pure science in an Institution which has Faraday as a patron saint, for it can in fact never be completely foreseen what the practical outcome of fundamental research will be. He felt that it was good for The Institution to devote time to lectures and discussions on such research. J. A. S.

# MILLIMETRE WAVES

On the 25th January 1961, Mr. W. E. Willshaw will lecture on 'Generation and amplification in the millimetre-wave field'.

Mr. Willshaw joined the scientific staff of the G.E.C. Research Laboratories in 1937 to work with the late E. C. S. Megaw on the utilization of 'short waves' (then 40cm wavelength) in special communication requirements. With the war years came absorption in the problems of the multiple-cavity magnetron and its applications, and in the rapidly growing field of microwave science. For several years after, he was head of a microwave research group at Wembley, which included in its interests the use of millimetre waves for communication.

In 1956, he became responsible for all valve research and development at the Wembley Laboratories and is at present head of the valve division.

## UTILIZATION

# AWARD AND EXPERIMENT

At the start of the meeting at Savoy Place on the 10th November 1960, in the presence of the President, the John Scott Medal, Scroll and Award were presented to Prof. F. C. Williams. The honour was conferred by Dr. T. H. Osgood, Scientific Attaché to the American Embassy in London, on behalf of the City Trusts of Philadelphia, for Prof. Williams's invention of the super-regenerative responder.

Mr. Osgood explained that the Award was established nearly 150 years ago by the Scottish chemist, John Scott, who was believed to have chosen Philadelphia to administer it because of his admiration for Benjamin Franklin, who made his home there. He knew that he spoke for the scientists and engineers of the United States when he said that they applauded the choice made for the Award as recognizing the imaginative character and high quality of science and engineering in the United Kingdom.

Prof. Williams, in accepting, stated that it was a coincidence that the only other honour of this nature he had received was the Benjamin Franklin Medal of the Royal Society of Arts. He reiterated what he felt to be John Scott's object in creating the Award: 'that prophets should not be without honour and that honours should not be without profits'. On this note he was congratulated by the President, as well as by the Chairman, Mr. J. M. Ferguson, to the applause of the audience.

Following this pleasant and interesting ceremony, two papers, which covered original work carried out at the University of Manchester, were read and discussed.

### Experimental induction motors

The first paper was 'The logmotor—a cylindrical brushless variable-speed induction motor', the authors of which were Prof. F. C. Williams, Dr. E. R. Laithwaite, Mr. J. F. Eastham and Mr. L. S. Piggott, who pointed out that, as the synchronous speed of an induction motor depends on the difference between currents in adjacent slots and the spacing of the slots, this may be increased by changing the phase of the current in each slot progressively, so as effectively to stretch the poles.

A transformer arrangement giving a multiphase output to effect this was described. This transformer is similar to a conventional phase-shifting transformer, except that the pitch of each coil of the primary is proportional to the logarithm of its distance from a fixed point in the system. The secondary is connected to the stator winding of the motor, whose rotor speed is varied by adjusting the position of the primary. A description was also given of the method of construction of an experimental motor embodying these arrangements, together with its test results over a speed range of 4:1.

The title of the second paper was 'Brushless variable-speed induction motors using phase-shift control', the authors being Prof. F. C. Williams, Dr. E. R. Laithwaite, Mr. J. F. Eastham and Mr. W. Farrer. This dealt with an alternative method of pole-stretching for induction motors, in which part of the stator windings are fed directly from the mains supply and part from phase-shifting transformers, variation of the angle of phase shift enabling continuous speed control to be effected. An experimental machine of this nature was described, and test results were given which showed that speed control is obtainable over a speed range of 1·5 : 1. A short review of these papers appears on p. 25.

### Challenge to past concepts

Mr. C. C. Inglis, who opened the discussion, welcomed the authors' challenge to past concepts and said that previous prejudices must not prevent the adoption of new ideas in the field of variable speed, which was of the greatest importance to railway electrification. Another speaker, in advising the authors to confine their efforts to making the phase-shift motor work reasonably well over a limited speed range, sagely remarked that 'a little done simply was better than a lot more done with many times the complexity'.

Mention was made of the development work on the spherical motor carried out by the aircraft industry with a view to the possibility of using this type of machine as an induction generator. Its weight/power ratio had prohibited this. The authors were taken to task by one contributor for not paying more attention to the economics of machine design—there was too much of a tendency 'to leave this to the manufacturer'.

In reply, Prof. Williams made a spirited defence of the authors' work, laced with some delightful touches of humour, one of which completely disarmed certain of his critics—he said that he felt that the definition of 'uneconomic' was 'something which could not be made without introducing a new process'.

R. H. R.

# LOUD AND CLEAR

A REMARKABLE frequency change took place in the Supply Section on the evening of the 16th November 1960, when it met at Savoy Place to discuss transmission at frequencies some million times higher than usual. The increased frequency has the advantage that interconnecting overhead lines or cables are not required; this saves money and, as several speakers pointed out, increases reliability. On the other hand, the power received is minute and often fluctuates rather wildly. The occasion was the reading of the paper by E. H. Cox and R. E. Martin on 'Radiocommunication in the power industry'; Mr. J. E. L. Robinson, Chairman, presided.

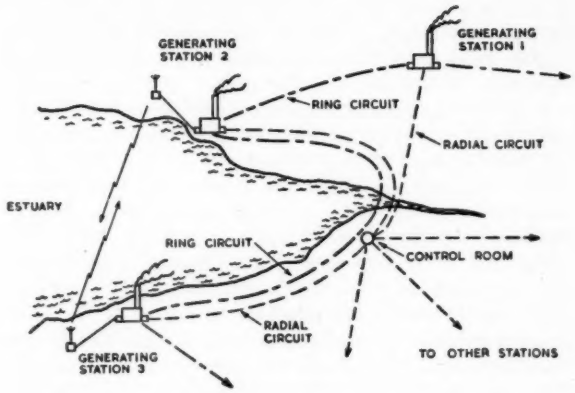
The authors illustrated their paper by an excellent film showing how v.h.f. radio can assist in the speedy restoration of supplies on a distribution system. A short review of the paper appears on p. 27.

The discussion was opened by Mr. G. F. Peirson (incidentally the talented amateur producer of the film), who referred to the part played by the authors in the introduction of radio into the electricity supply industry. Mr. Cox is Chairman of the Midlands Board Radio Committee, and Mr. Martin has been closely associated with the subject since the initial researches on the application of v.h.f. radio in the industry were started at the Central Electricity Research Laboratories many years ago.

Mr. Peirson emphasized the great assistance given by radio in emergency operations and consumer services. He cited an instance in which a housewife had reported in some trepidation from a call-box that the cooker was faulty and the dinner was being ruined. Before she returned from the call-box to her house (a distance of 200 yards), the service van was at her door.

### Passing the buck

Other speakers were nicely balanced between manufacturers and users, and the discussion turned to the question of reliability, quality and price. With regard to equipment failures, the users blamed the manufacturers, and the equipment manufacturers said that the trouble was due to poor-quality components, and the matter was left there—presumably because no component manufacturers were present.




Several speakers felt that the supply industry had not received a fair share of frequency allocations. The industry had voluntarily, and at some self-sacrifice, taken the bold step of adopting 25kc/s channelling, while other users continued to make extravagant use of the frequency spectrum.

In their reply to the discussion, the authors made a plea for a slice of the v.h.f. (and the u.h.f.) spectrum, which they would utilize as efficiently as possible for essential services.

J. S. F.

# AVOIDING DISAPPOINTMENT

THE very popular Dinner-Dance of the Section will be held on the 9th March 1961 at the Connaught Rooms, Great Queen Street, London; and members are urged to make application as soon as possible on the requisite form, which is being distributed to members of the Section with the January *Journal*.

F. C. W.



# GIVEN A ROCKET

ON the 1st November 1960, at Savoy Place, we were entertained in a very lively lecture by Mr. G. G. Haigh on his experiences in using transistors in rocket instrumentation. Mr. C. G. Garton was in the Chair. We were left in no doubt as to the depth of Mr. Haigh's experience—as far as he was concerned, his transistor circuits were no better than they ought to be. Listen to the voice of experience here: the greatest practical difficulty is caused by the shortage of rocket engineers with an understanding of the operation of a transistor; this makes a transistor instrument into a much darker black box than its valve predecessor.

One must confess, however, on the evidence of the five excellent demonstrations that were given with transistorized instrumentation, that the transistor can be pretty co-operative. It was interesting to hear that the reduction in weight, which is so obvious with the use of transistors, is not their main advantage in rocket work. The chief advantage is the low impedances used with the transistor, which practically

eliminate the old bugbears of pick-up and crosstalk, allowing extreme latitude in the lay-out of components.

Mr. Haigh went into the mysteries of potting and, in an astringent aside, mentioned the difficulty of mining components which were defective. Many a good valve man in the audience winced when a flux-gate magnetometer was banged on the desk, but it was subsequently found to be working perfectly.

A series of d.c./d.c. saturating-core convertors was demonstrated with complete success (with one exception) over a remarkable range of load and supply variations. Neither were we denied the latest news of the advantages of the mesa diodes in a diode-chopper circuit. An article on this topic will be published in a future issue of the *Journal*.

Space-fiction fiends will be glad to hear that no failures have been experienced in the Skylark rocket due to cosmic radiation. However, space travel has its difficulties, for heat, once generated, cannot be dispelled and just accumulates, and, while a transistor leads to less heat generation in the circuits, it is also limited to an 80° F maximum as against 200° for the valve.

### Representing the customer

After the lecture, there was a lively discussion opened by Mr. M. James, who commented on the limitations of channel capacity in telemetery for rockets. He wondered how Mr. Haigh managed to strike a compromise between the reliability of well tried circuits and the superior handling capacity of the latest, but not so well tried, device. He wanted to know where magnetic amplifiers figured in this story and what were the prospects of true solid circuits.

Mr. L. J. Ward, representing, as he said, the customer, noted the odd characteristic of users who were prepared to consider throwing away a potted circuit but were unwilling to throw away a bulky valve-chassis at half the price. For himself, he, not unkindly, was all in favour of throwing away unit circuits. He regarded this as a healthy trend. Mr. Ward had had his fill of potting and favoured dip-coating techniques.

In his reply, the author said that he agreed with Mr. James that the channel capacity of telemetery is small for the complexity of gear in the air, but that more information is conveyed and is available on the 10c/s band used than can easily be handled by the number of people available to analyse it. He expressed a weakness for the Skylark rocket for its characteristic of having no two alike. Of magnetic amplifiers, he confessed he was prejudiced by the amount of low cunning required to accommodate them to the circuit, as opposed to transistors which were so simple to play with and so accommodating to devise circuits for. Of solid circuits, he felt that these were a new complication for which he was not yet fully prepared.

In an aside on printed circuits, he commented on how troublesome they were to get through the drawing-office, while physical wiring could be done in an afternoon! He entered the lists whole-heartedly on the side of the throwers-away of defective assemblies. This was a most refreshing evening, attended by a small audience of keen circuit enthusiasts.

J. H. W.

---

# LONDON REPORT

## JOINT MEETING OF THE THREE INSTITUTIONS

## TRAINING FOR OVERSEA ENGINEERS

At a Joint Meeting of The Institutions of Civil, Mechanical and Electrical Engineers on the 3rd November 1960 at Savoy Place, Dr. W. Abbott presented his paper on 'The training of oversea graduate engineers, with particular reference to the F.B.I. scholarships scheme'. Sir Herbert Manzoni, President of The Institution of Civil Engineers, was in the Chair. This paper is reviewed on p. 31.

It came as no surprise to those who had read Dr. Abbott's paper that in his view the training that oversea graduate engineers were receiving in this country was far from satisfactory. But the extent to which he expressed his deep concern in his introductory remarks, coupled with his obvious sincerity of purpose, had a marked effect on the audience. There was no equivocation in his comments and he gave good reasons, backed by very pertinent illustrations, why he believed them to be well founded, and stressed how too often training fell short of what was necessary.

### Harmony or disharmony

Dr. Abbott said that because the F.B.I. scheme dealt with young men from so many oversea countries, and because they were chosen as possessing the qualities of leadership, he believed their reports placed us in the position of being a kind of sounding-board for the harmony or disharmony of many postgraduate industrial training arrangements.

His paper constituted an attempt to estimate the size of the training load falling on industry; to deal with the influence of the Institutions and to compare their requirements; to outline the main complaints received by the F.B.I.; to discuss possible ways of ameliorating these defects; and to take a glance at future developments.

He stated at the outset that the training picture presented was vastly complicated, not lending itself to generalizations, which would surely be misleading. He then ventured two suggestions: first, that in debating the issues we should try not to be too much influenced by our own experiences—today differs from yesterday and will be unlike tomorrow; secondly, that we should not assume that there is anything like uniformity in industrial training schemes—some are beyond praise, some are beneath contempt, and lots lie between these two extremes.

The first question that he felt might arise was what weight

should be attached to the criticisms of these young men: do they really know what they want, and perhaps we ought to know best.

### From China to Peru

In the first place, he explained, these youths had come to us, literally from China to Peru, shortly after having spent years in a university—in Latin America as long as five years. They had all been encouraged to think for themselves; that was what universities were for—and why they must be free. Intellectual courage was the most precious thing we could try to give young people. They were made in the image of God and they had a right to ask awkward questions, even of the Creator. Consequently, the first reaction of such a person to an instruction, 'do this', was 'why'? And this kind of reaction had a high nuisance value. It was a reaction that Dr. Abbott delighted in, although it gave him much work.

When those who require industrial experience first come to him, he expounds to them what hitherto was thought the right kind of advice: that they should have experience in the pattern shop, foundry and fitting, welding and machine shops, followed by experience in erection, testing, estimating, the drawing office, etc. By the end of this period of two years, it is thought, a knowledge will have been secured of a manufacturing unit and of production techniques. Some students accept this programme and see it through, although they make it quite clear, particularly if they will not be producers, that a different plan would suit them better; they have the sense to see that they will be fitting into a scheme devised for British graduates, and they conform.

But many do not conform at all. They have come to this old country, the very cradle of engineering, with tremendous hopes, and they are speedily disillusioned. The Latins tell us so with extreme courtesy; the Australians have a more pungent vocabulary.

### 'E'll want some overalls'

He then gave a few examples. One graduate from Brazil was given the job of drilling holes in plates, and as this went on for weeks he wrote a sensible letter saying that he really must protest. He said that for five years his intellect had been stretched and he wanted to use it. His job required no intelligence, and he had not even been able to find out what it was that went into the holes he had drilled. Another, from the Argentine, spent so long closing rivets in an aircraft fuselage that he gave up and stayed at home. Another found himself for months in a special training shop for young apprentices.

Another, in a chemical-plant works, was bewildered by the steelworks operations and completely confused because he could not easily find out what the bits and pieces were for; he badly wanted guidance and advice. Dr. Abbott had to telephone recently about a new arrival, a very able and cultured person; the voice at the other end of the line said: 'Yes, we're expecting 'im. 'E'll want a couple of suits of overalls. We've got a lathe and plenty of work for 'im.' These and similar cases reflected an acquiescence on the part of management, coupled with a most stupid subsequent neglect. He warned against dismissing these examples as being odd or rare: they were all too common.

There was of course another side to the coin, he went on. Where the graduates are put on development work, all is well. Nothing but satisfaction is expressed by men who go to Marconi College. As far as he knew, there have been no complaints from the many men who have gone to the Electricity Authority. The reason was an obvious one: they are in contact with professional men all the time, who can not only direct their work but answer their questions. For the same reason, graduates were generally very satisfied with the training they got with consultants, civil and electrical.

He felt sure that the bulk of oversea graduates resent any time spent on the acquisition of craft and machine skills. They want only a nodding acquaintance with these, whatever we may recommend. They will not have to use them, and they are unimpressed by the argument that the British engineer can, if necessary, take his coat off and do the job himself. They say that this is not a sensible division of labour. When we quote the willingness of our own graduates to accept this kind of training, they assert that our own men conform because they have to, but that in fact they strongly disagree with the use which is made of them.

He had constantly asked our own men for their views and found them substantially as described; and he wondered whether the Institutions had made comprehensive inquiry of the men now actually in training. Perhaps we are in fact making a colossal mistake, one which could well be to our grave injury. He invited us to think about this with unprejudiced minds.

### Greybeards of thirty

Presumably one argument in favour of what we do rests on our reputation as craftsmen and technicians; rests on what is called our rich heritage of craft processes and techniques. He did not believe that this heritage was uniquely British or uniquely European. He felt craft skills were widespread throughout the human race. He pointed to what feudal Japan had done in our lifetime; also to how quickly the Russian moujik had been converted into a good craftsman. No doubt, he said, the Chinese were as cunning with their hands as the best of our own people. He cited the way in which a Nilotic tribe in the southern Sudan dealt with textiles. And, on this evidence, he believed that our heritage was not a unique one and that we courted disaster if we relied on it.

With those who say that it is surely necessary for our professional engineers to know a good deal about craft techniques, Dr. Abbott would agree, if these techniques were static and unchanging. But, in his view, they are not. Change is continuous; and the only certain thing is that change will continue and will accelerate. To familiarize our precious youth *too much* with our existing methods is to make it less likely that they will introduce new ones. We must never forget that creation is to the young, particularly if it involves the use of advanced mathematics. He said that he used the word creation instead of invention deliberately.

He recalled that Newton was only 24 when he gave us the great idea of fluxions and that of the law of gravitation. He

had attended a convention on servomechanisms where only the young graduates could follow the pace; the old greybeards of 30 had been at a disadvantage.

The speaker believed that we were largely misusing our graduates during their training period in industry. Their keen minds should be employed in attempting to find solutions to the endless problems confronting us in the fields of design, development, controls, automation, metrology, standardization, etc. They will put up plenty of impossible and perhaps ridiculous proposals—but among them may be a few priceless ideas.

He anticipated that many mature engineers would scoff at this suggestion. He cited one such who said to him recently 'I find the attitude of these Cambridge graduates insufferable. Give me a sound H.N.C. man every time'. This, said Dr. Abbott, is just what a ploughman would say if given a couple of highly trained race-horses; he wants the shire horse every time. But we have no lack of men coming along with H.N.C. and relatively few graduates: fewer still very able graduates.

### The inertia of the mass

He then attacked the problem of change. What kind of change could we aim at? He thought The Institution of Civil Engineers had clearly shown the way through trying to make the training of the coming generation the responsibility of professional members. The difficulties of applying this principle to industrial training were obvious, he said, but he could not believe that they were insuperable. He knew only too well the inertia of the mass that had to be moved, the inertia of well meaning men who had come up the hard way and who were unsympathetic to the university product.

He himself was old, he said, and had come up the hard way. He gave a faithful vignette of a part of his early training. At the age of 14, he entered Portsmouth Dockyard to be trained in mechanical engineering and served an apprenticeship of six long years. During this period he worked on a cruiser undergoing refit. She was the *Good Hope* and had, he believed, the largest engines ever made. Her crank pins were 24 in. in diameter, had worn oval, and had to be trued *in situ*. How was it done? By filing. The fitters filed day after day, working by candle-light and checking their progress by half-cylinders. As they worked, they chewed tobacco and spat. It was a repellent experience for him. He went home exuding an unpleasant metallic odour like the London Underground on a wet day.

He stated that, after this sort of practical training, he might be expected to endorse it for others. On the contrary, it was a dreadful, stupid method, in his view. He advised that the Admiralty should have collected a few of the sixth-year apprentices and said 'Watch this awful process, which dates from Noah. Get your drawing-boards out and devise a machine to do this job'. And that is what we should be saying now to our bright graduates, he concluded.

Dr. Abbott explained that we are a small country with few natural advantages. We have a large population and a very high standard of living. We are going to face competition in the future, the fierceness of which will be unparalleled. If we are going to ride the waters and prosper, we shall want every new idea that we can get. He submitted that we should most likely get these from our educated youth. He suggested that it was our urgent duty, working through the three great engineering Institutions, to ensure that these young men should go only to those organizations which were conscious of their responsibilities and which would use talent effectively.

How can we bring this about? This was the main question he left for discussion.

### All is not well

In the sequel, the challenge was not taken up, even though the discussion revealed a general acceptance that his concern was more than justified. Fortunately, the meeting was in the main spared those biographical comments concerning the kind of training that individual speakers themselves had received in the past, using them to justify some present practices.

Sir Herbert outlined the philosophy of the I.C.E. in making the training of their future members the individual responsibility of Chartered Civil Engineers, and he welcomed Dr. Abbott's favourable comments on this approach. Yet all is apparently not well, for Mr. C. G. Bevan, an F.B.I. civil engineering scholar from Rhodesia, was moved to comment that, if consultancy is held out to be the shining example, he despaired of the training given in other branches of engineering. He felt that even in consultancy too much was left to chance on the appropriateness and value of training that a graduate received, and he considered that the Institutions could profitably set out training syllabuses in greater detail.

It was Mr. R. G. Bellamy who explained why the last suggestion would not have the effect intended. He thought that dissatisfaction with training was often due to rigidity of programmes; success depended on individual treatment of scholars. A programme should be planned with each scholar, provided that this could always take account of what he referred to as the healthy desire of graduates with increasing experience to vary their programmes. Individual assignments, too, must be so arranged that trainees are given work of reasonable responsibility, about which they also have the opportunity to inquire and pick the brains of professional engineers.

### The heart of the matter

Oversea trainees themselves were the subject of some comment. Mr. R. F. Marshall referred to their tendency to want to make frequent changes in their assignments and said that the value of such experience could be very superficial. On the other hand, as Mr. L. C. Crouch commented, this habit of trainees was not nearly so noticeable when they were engaged on work, such as electronic development, which made demands in keeping with their academic training.

In assessing the value of training, Mr. G. S. C. Lucas questioned the wisdom of paying too much regard to the comments of trainees themselves; more valuable would be the views of those who had completed their training some two to five years previously. Some criticism was expressed by Mr. J. A. Kline of Australia concerning the F.B.I. scheme itself and its administration. The value of the scholarships was not nearly sufficient, and he was even more critical of

the methods of selection. He was quite firm in his view that from Australia the best men were not being attracted by the F.B.I. scheme.

One left the meeting with the impression that the author was not alone in being disappointed with the discussion in that it did not get down to the heart of the matter. For oversea graduates it is important not to overlook the special nature of their professional needs when they return to their countries; and we must also be fully mindful of the great goodwill they will have for this country if they see their training and experience to be of real value. In these respects, oversea graduates make a special claim on our attention.

But if the principal comments and concern expressed by Dr. Abbott have any foundation, which undoubtedly they do, they apply equally well to the training of all graduates. The reasons are just as strong to provide effective training for British engineers as they are to provide it for those coming to this country from oversea. W. H. T.

JOINT MEETING WITH THE INSTITUTION OF CIVIL ENGINEERS

# THE ASWAN HYDROELECTRIC SCHEME

At a Joint Meeting of The Institution with The Institution of Civil Engineers, held on the 22nd November 1960 at Great George Street, London, Messrs. V. Furuskog and G. F. Kennedy presented their paper on 'The Aswan hydroelectric scheme'. Sir Hamish MacLaren was in the Chair.

### Irrigation of the Nile

The water of the Nile was absolutely vital to Egypt's survival; without it, irrigation of the land was impossible. Reservoirs, capable of storing some of the millions of gallons of water discharged annually into the sea east of Alexandria, had to be constructed. The first and largest of the control works built was the reservoir at Aswan. This was completed in 1902 and heightened in 1911 and again in 1933. The height of the present dam was 38m, and it held back 5000 million cubic metres of flood water.

Engineers realized long ago the enormous power potential represented by this stored water, and, as early as 1932, plans for a hydroelectric project were made. It was not until 1945, however, that the Hydro-Electric Power Commission for Egypt was set up by the Egyptian Government. The Commission authorized the construction of the 350MW Aswan Hydroelectric Scheme, and the first contracts were signed in May 1953. The project, now nearing completion, had cost nearly £30 million.

The paper described the main features of the civil engineering works. The principal mechanical and electrical characteristics were also outlined.

### Kaplan turbines

The generating plant comprised seven 47MW and two 11·5MW vertical Kaplan turbines and alternators. Kaplan turbines were chosen because they were capable of operating efficiently at the varying heads (10–23m net) which occurred. Peak efficiency on all the main turbines occurred at about three-quarters of the full output and was guaranteed to be between 91 and 92%. The generators were of the conventional salient-pole design with tangentially mounted air coolers round the stator periphery for closed-circuit cooling.

Each of the seven main 47MW generators was connected to a 51MVA 11/132kV transformer, which, in turn, was connected to the 132kV busbars in the outdoor switching station. The two 11·5MW house units were connected to an indoor 11kV switchboard. The house-service 3·3kV busbars were fed from this switchboard through two 3MVA house transformers. Aswan Town was to be supplied from the 11kV busbars through feeder switches. The surplus energy generated by the two house units was fed to the 132kV system by an interconnection between the 11kV busbars and two of the main 51MVA transformers.

The main 132kV switchgear was of the outdoor type and was rated at 2500MVA. It was situated about 250m from the main station building. The station was of the double-busbar type with bus coupler, and all switches and isolators were remotely controlled from the power station.

### Controls and auxiliary services

The control-room building accommodated the 11kV metal-clad switchgear, a relay room, and the main station control room. The control panels governed the 132kV and 11kV switch equipments for generator, auxiliary transformer and feeder circuits. The control desk contained the governor and exciter controls, an automatic synchronizing system, and visual and audible alarms to indicate turbine and generator faults.

The 3·3kV busbars fed the auxiliary services for the turbine, generator and transformer units, and all supplies were duplicated for standby purposes. Power for essential auxiliaries was obtainable from two 400Ah batteries in the event of failure of all a.c. supplies. All main and auxiliary transformers were protected by an automatic Diesel-pump-operated water-emulsification system; the generators were protected by carbon dioxide.

A colour film of the construction of the main parts of the scheme was shown by the authors.

### Design changes

While the discussion was mainly concerned with the civil-engineering aspects of the scheme, such as the power-house superstructure, one or two interesting electrical engineering points were made.

One speaker considered that there was nothing controversial about the electrical equipment itself. It was unusual, however, that the generators could not be uncoupled from the transformers except by unbolting. The local area load was also unusual.

Another speaker thought the main generators would be substantially changed if designed today. Fire protection of the generators by carbon dioxide was now obsolete. In reply, it was pointed out that the orders were placed in 1946–47.

DISTRICT MEETING AT OXFORD

## FFESTINIOG PUMPED-STORAGE SCHEME

MR. V. G. Newman, of the Central Electricity Generating Board, gave a most interesting talk to 60 members and friends at the Southern Electricity Board's Demonstration Room at Oxford on the 9th November 1960. Mr. J. L. Taylor was Chairman.

Childhood memories of a rhyme about the noble Duke of York were revived as Mr. Newman described this novel and interesting project, whereby millions of gallons of water are pumped up the hill during off-peak periods, only to return via the turbines during peak periods. Of great interest were the economic considerations, involving comparisons with converted oil or coal power stations, nuclear power stations, and the transmission costs incurred.

**Reliable crystal ball**

Almost disturbing was the derived observation that the parameters can change so rapidly that a project which is attractive when planned might no longer be so at completion. It seems that planners of large power sources need a reliable crystal-ball attachment to their slide-rules. With the aid of slides, Mr. Newman gave a clear explanation of the engineering details, covering civil, mechanical and electrical aspects of the scheme.

Following a break for refreshments, many questions were asked and ably answered in the discussion. Mr. W. F. Sands proposed, and the members heartily supported, a vote of thanks to Mr. Newman for a very interesting and informative evening.

J. L. T.

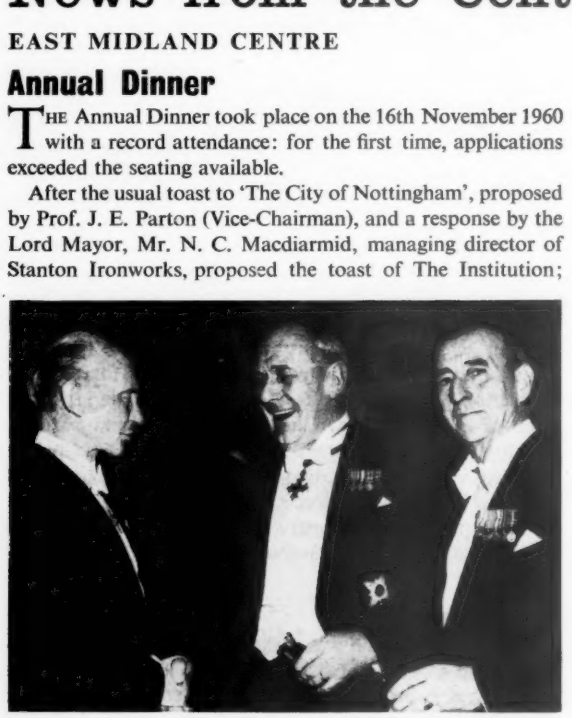
# News from the Centres

EAST MIDLAND CENTRE

## Annual Dinner

THE Annual Dinner took place on the 16th November 1960 with a record attendance: for the first time, applications exceeded the seating available.

After the usual toast to 'The City of Nottingham', proposed by Prof. J. E. Parton (Vice-Chairman), and a response by the Lord Mayor, Mr. N. C. Macdiarmid, managing director of Stanton Ironworks, proposed the toast of The Institution;



*The President, Sir Hamish MacLaren, welcomes Sir Robertson King at the Annual Dinner of the East Midland Centre. On the right is the Centre Chairman, Lt.-Col. W. E. Gill*

this was a most witty and polished speech which caused Sir Hamish MacLaren to coin the word 'superadequately'. Sir Hamish also hoped all members knew The Institution's history and objects as well as Mr. Macdiarmid.

The speeches covered subjects which included the comparison of old and new customs—i.e. the burial of suicides at cross-roads to confuse the spirits, and the present gyratory traffic systems which confused everyone else—as well as the education of young engineers and support for the Benevolent Fund. These were generally full of wit and good-natured banter between Scots and others, with further reference to the Services in which so many of the members and guests had served with distinction.

The speakers held the attention of their audience so well that most were surprised to note that it was nearly 11 p.m. before the reunion began.

## Dinner-Dance and Faraday Lecture

The Annual Dinner-Dance is to be held on the 17th February 1961 at the Victoria Station Hotel, Nottingham.

The Faraday Lecture will be given on the 2nd March 1961, beginning at 7.15 p.m., at De Montfort Hall, Leicester, where Mr. L. J. Davies will speak on 'Transistors and all that'.

Members are requested to make early application for tickets for these events to the Hon. Assistant Secretary.

## Inaugural Meeting

A very successful Inaugural Meeting of the Bedfordshire Sub-Centre took place at the Swan Hotel, Bedford, on the 21st November 1960, when approximately 100 members and 20 visitors attended.

The chair was taken by the Chairman of the East Midland Centre, Lt.-Col. W. E. Gill, who welcomed the guests and gave a résumé of how the Sub-Centre came to be formed. Mr. J. Russell Taylor then gave his Chairman's Address entitled 'Trouble'—a most informative and amusing talk. An article based on the talk will appear in a future issue of the *Journal*. Following his induction as Chairman, Mr. Taylor invited Mr. C. T. Melling, a Vice-President of The Institution, and Mr. W. K. Brasher, Secretary, to say a few words, after

which Mr. W. E. Swale gave a short talk on the Benevolent Fund.

Among the visitors who attended were Mr. A. B. Vickery, managing director of Brookhirst Igranic, Bedford; Mr. W. H. Cashmore, director of the National Institute of Agricultural Engineering, Silsoe, Beds.; Mr. J. H. Stephenson, Chairman of the Eastern Centre of The Institution of Mechanical Engineers; and representatives of colleges, schools and industrial concerns in the area of the Sub-Centre. O. S. W.

## MERSEY AND NORTH WALES CENTRE

### Opening meeting

At the opening meeting of the session held in the Liverpool Royal Institution on the 3rd October 1960, Mr. Donald A. Picken was installed as Chairman and gave his Address on the effects of electricity on human beings.

To fill a Committee vacancy, Mr. H. M. Rostron was co-opted to serve for two years.

### Annual Dinner and Dinner-Dance

The Annual Dinner held at the Adelphi Hotel, Liverpool, on the 7th November 1960 was graced by the President of The Institution and proved a real 'Naval occasion'. The toast of The Institution was proposed by Admiral Sir Michael M. Denny, chairman of Cammell Laird and formerly Third Sea Lord and Controller, Royal Navy. He reviewed developments during his 50 years in the Service, from the time when he joined *Neptune*—a dreadnought—to the recent passing of *Vanguard*, and he acknowledged the debt owed by the Navy to the professional electrical engineer in the changes brought about by the development of electrical devices.

Responding to the toast and, as he said, 'fulfilling his first assignment', Sir Hamish recounted that just a week earlier he had vacated the position of Director of Electrical Engineering which he had held for 15½ years, almost half his length of service. He paid a personal tribute to Admiral Denny, to whom, as Third Sea Lord, he had been accountable.

*At the Mersey and North Wales Centre Annual Dinner on the 7th November 1960*

From left to right: Mr. S. Towill; Admiral Sir Michael Denny; Mr. T. A. P. Colledge; the Lord Mayor of Liverpool, Alderman John Leslie Hughes; Mr. D. A. Picken; Sir Hamish MacLaren; Mr. W. K. Brasher; and Mr. A. F. Behrend

Concerning the future policy of The Institution, the President summed up his viewpoint as being, while not in favour of amalgamation, definitely opposed to any form of fragmentation.

The guests included the Lord Mayor of Liverpool, Alderman J. L. Hughes; the Secretary of The Institution, Mr. W. K. Brasher; the representatives of sister institutions and learned societies; and Chairmen from our neighbouring Centres. Their health was proposed in breezy fashion by Mr. T. A. P. Colledge and replied to on their behalf by Mr. A. F. Behrend, founder of Burton Manor Residential College.

The Chairman, Mr. Picken, presided.

#### Forthcoming

The Annual Dinner-Dance has been arranged to take place on Friday, 24th March 1961, at Hulme Hall, Port Sunlight.

E. W. A.

## NORTH STAFFORDSHIRE SUB-CENTRE

### Porcelain insulators

The opening meeting, held at Stoke on Trent on the 7th October 1960, commenced under the chairmanship of Mr. A. Asbury, the retiring Chairman, who had the pleasure of presenting premium certificates to Mr. A. D. Hawkins and Mr. G. F. Horobin for their Graduate and Student Section paper on 'The magnetic amplifier'. After formally welcoming three new Corporate members, Mr. Asbury introduced Brig. F. Jones, Chairman of the South Midland Centre.

Brig. Jones said he was glad to visit the Sub-Centre, as he had not been to Stoke before. He mentioned that this was the diamond-jubilee year of the Sub-Centre and it was proposed to hold a three-day convention to mark the occasion, the programme for one day each to be arranged by the Centre, the Rugby Sub-Centre and the North Staffordshire Sub-Centre. Ideas were nebulous at present, and suggestions would be welcomed by the sub-committee arranging details.

The Chairman then invited Mr. G. H. Gillam to give his Inaugural Address on 'Outdoor porcelain insulators', in which he first briefly traced the history of the manufacture of porcelain and then described in some detail the manufacturing and testing techniques and the problems associated with porcelain insulators. He referred to factors in design which contributed to satisfactory service even in conditions of serious pollution. Porcelain, he said, was a unique engineering material in that, after it had been shaped in the plastic state, it shrank during drying and firing by about 14%, two-thirds of this amount occurring during firing. Machining after firing could be done only by grinding.

Dr. T. E. Calverley proposed a vote of thanks, in which he referred to the international reputation held by Mr. Gillam in the field of porcelain-insulator design, and complimented him on his interesting and informative presentation of the subject. He thought that, while alternatives had been suggested, the modern switch-yard showed the confidence placed in porcelain for this very important duty.

Mr. Gillam then took the Chair and, after expressing thanks

for the honour conferred on him, proposed a vote of thanks to Mr. Asbury for the excellent way in which he had directed the affairs of the Sub-Centre during the preceding year and especially for his work in committee, conducted with efficiency, charm and humour. A copy of 'The history of The Institution' was presented to Mr. Asbury by Brig. Jones as a memento of his year as Chairman of the Sub-Centre. The proceedings terminated with refreshments and the usual informal conversazione.

## Annual Dance

It was decided to hold the Annual Dance earlier in 1960, in the hope of avoiding clashing with other functions, but perhaps the 14th October came before many of the members had entered into the swing of the new session, and the attendance was still rather disappointing. In spite of this, the event again proved to be a thoroughly enjoyable social occasion and 'get together', not only for the members but also for their ladies. The prizes won during the dancing were gracefully presented by Mrs. G. H. Gillam, and all who had worked for the success of the evening were thanked by the Chairman.

## Shielding against lightning

'The shielding of overhead lines against lightning' was the title of the paper read by Dr. J. H. Gridley at Stafford on the 17th October 1960. The author outlined the considerations governing the placing of an earth wire above the phase conductors of an overhead line, basing his theory on modern knowledge of lightning and the charges bound on the earth wire and phase conductors by the leader stroke. The paper was illustrated by some interesting slides showing lightning discharges. A short article based on the paper appeared on p. 221 of the April 1960 *Journal*.

Mr. W. P. Williams opened the discussion and referred to the difficulty of correlating practical results with the various theories put forward. A large number of members joined in the discussion, and Dr. T. E. Calverley, in proposing a vote of thanks to the author, referred to this as an indication of the wide interest aroused by the subject. Dr. Calverley mentioned a colleague who, having been affected by lightning while golfing, presumably by a high concentration of charge at the head, later found a surge diverter on his desk! L. G.

### SCOTTISH CENTRE

## Glasgow Dinner-Dance

THE Centre was very pleased, at the Glasgow Dinner-Dance on the 15th November 1960, to have in the Chair Mr. R. B. Anderson, who had hitherto been prevented by serious illness during the summer from taking over his active duties as Centre Chairman. The welcome given to him by the 300 members and guests present and the obvious success of the function must surely have helped his convalescence.

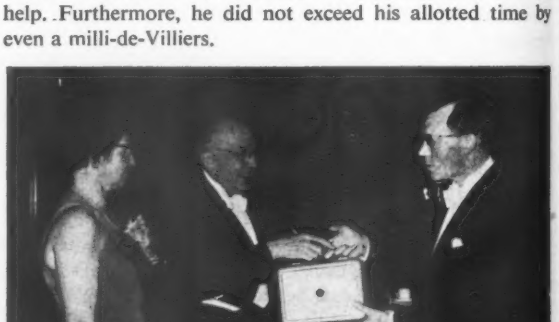
The toast of The Institution was proposed by Lord Strathclyde and replied to by the President, Sir Hamish MacLaren, so that the summit of the top table had an unusually Scottish aura, the last Scottish President having been in 1948. The toast of the guests was proposed by Mr. W. L. Kidd, Chairman of the South-West Scotland Sub-Centre, and admirably replied to by Mr. J. Malley, Deputy Chairman of the Scottish Branch of The Institution of Mechanical Engineers.

### Presentations

The Hutcheson–Winning Golf Trophy, played for in the previous spring and won for the third time by Dr. J. Jamieson, was presented by Mrs. Anderson, who suggested that the award might well be renamed the Hutcheson–Winning-Jamieson Trophy.

A further presentation was made by Mr. J. A. Aked, Immediate Past-Chairman, of a cine projector to Mr. and Mrs. J. H. P. de Villiers to mark the appreciation of the members for their work for the Centre over many years; Mr. de Villiers recently resigned from the post of Honorary Secretary and Treasurer, having previously been Assistant Honorary Secretary and also Honorary Secretary of the South-West Scotland Sub-Centre, and his extremely effective handling of these offices was very actively and graciously supported by Mrs. de Villiers.

Although it was unusual for Mr. de Villiers to be at the receiving end of the highly accurate time schedule that he had built up for Institution dinners in Scotland, he replied expressing grateful thanks to the members for their kindness and to his assistants, particularly Mr. David Rollo, for their help. Furthermore, he did not exceed his allotted time by even a milli-de-Villiers.



*Mr. J. A. Aked presents Mr. and Mrs. de Villiers with a cine projector*

The formal proceedings concluded with a vote of thanks to the Chairman proposed by Mr. W. B. Laing, Senior Vice-Chairman, after which dancing was enjoyed until 1 a.m.

E. O. T.

### TEES-SIDE SUB-CENTRE

## Ships and power convertors

THERE was a good attendance on the 5th October 1960 at the opening meeting of the session, when our new Chairman, Mr. T. W. J. Temple, gave his Address on 'Turbo-electric propulsion for ships'.

In presenting his Address, Mr. Temple said that it was

not his intention to consider the case for turbo-electric propulsion as compared with other types of conventional transmission for ships, but rather to talk about the general principles of electric drive and to endeavour to trace the progress in design and performance over the last 40 years.

Reference was made to some of the more important installations which had been commissioned during this period, and, for the purposes of comparison, the first British-built turbo-electric-propelled vessel, completed in 1921, was described in detail. This was followed by a description of the largest and most up-to-date British equipment, which had been installed in the P. and O. vessel *Canberra*, the biggest passenger liner to be built in Great Britain since the *Queen Elizabeth* and, incidentally, the first British liner to have all auxiliaries powered by alternating current.

By means of this description, it was possible to emphasize the main features and advantages of turbo-electric drive; and it was stressed that, while the ship's main propulsion turbo-alternator was not unlike a land unit, generally speaking it was not desirable to make a comparison with power-station practice in approaching the question of marine electric drives, because the propulsion sets had to be designed for their particular application in operating conditions which were peculiar to the propelling of the ship and where the alternator and propeller were best visualized as a unit with the simplest form of interconnection, consistent with the method of ship control.

On the 2nd November, Mr. McBreen read his paper 'Some considerations in the application of power rectifiers and convertors'. This was well received and was followed by a lively discussion.

## Annual Dinner

The Sub-Centre Annual Dinner was held on the 11th November 1960 in the Zetland Hotel, Saltburn. In spite of stretching the hotel facilities to the apparent limit some years ago, successive functions have seen a regular increase in attendance, and this year we report a new record number of 169 (following successful negotiations with a long-suffering management). The Chairman, Mr. T. W. J. Temple, presided.

The Bishop of Whitby, the Rt. Rev. Philip Wheeldon, in proposing the toast of The Institution, took as his text, as it were, the objects of The Institution—interpreted broadly as increase of knowledge, fellowship and adventure. While acclaiming the spectacular advances made by electrical engineers in following these ideals, the Bishop warned against a one-track mind and the danger of regarding specialization as an end in itself.

Mr. Brian Donkin, our Vice-Presidential guest, responding, spoke of the importance of striving to maintain good lines of communication between the Council of The Institution and its members up and down the country. He was pleased to note the increasing membership of the Sub-Centre.

### Into the small hours

Great pleasure was had from the neat and entertaining speech by Mr. M. A. Raisbeck, Past-Chairman, who proposed the toast of the guests; and the response was made by Mr. A. P. Peaker, the Stipendiary Magistrate of Middlesbrough, whose infectious, boisterous humour put his audience in great spirits.

In addition to the speakers, we were happy to welcome as guests Mr. D. H. Thomas, Mr. R. Bruce and Mr. E. A. Sims (Chairman and Joint Honorary Secretaries of our parent Centre), Lt.-Col. D. T. W. Gibson and Maj. D. P. Garnons Williams (Convener and Honorary Secretary of the Catterick Camp District Meetings), and Mr. R. E. Mate.

The ever-popular reunion continued into the small hours.

*A group at the Tees-Side Sub-Centre Annual Dinner, 11th November 1960*

(left to right) Mr. D. W. Pattenden (Sub-Centre Hon. Secretary); Mr. R. E. Mate; Mr. B. Donkin; Mr. T. W. J. Temple (Sub-Centre Chairman); The Bishop of Whitby, the Rt. Rev. Philip Wheeldon; Mr. M. A. Raisbeck (Past-Chairman); and Mr. A. P. Peaker (Stipendiary Magistrate of Middlesbrough)

## Variable-speed motors

The two papers by Prof. F. C. Williams and associates, 'The logmotor—a cylindrical brushless variable-speed induction motor' and 'Brushless variable-speed induction motors using phase-shift control', were ably presented on the 7th December 1960 by Mr. J. F. Eastham, and much interest was shown in the equipment demonstrated. Warm tribute was paid by members of The Institution to the inventive genius and application of the Manchester University team.

N. M.

### OVERSEA ATTENDANCE REGISTER

DURING the period 17th November to 17th December 1960, these members called at the Institution building and signed the Attendance Register of Oversea Members:

HOUGHTON, B. W. (Aden)
JONES, J. H. M. (Lagos, Nigeria)
MEADE, J. (Frankfurt)
MUNRO, A. (Salisbury, S. Rhodesia)
MURRAY, C. C. (Lushoto, Tanganyika)

## SWEDEN JOINS POWER EXCHANGE

SWEDEN has notified the Organisation for European Economic Co-operation of her intention to join the power-exchange scheme sponsored by that body. She thus joins Austria, Belgium, France, Germany, Italy, Luxembourg, the Netherlands, Spain and Switzerland, which already freely exchange supplies of electric power.

Power exchanges between these countries take two forms: 'occasional' exchange, with the purpose of avoiding wastage of hydroelectric power or of providing emergency supplies to a network on which a technical breakdown has occurred; and 'seasonal supplies', which can be furnished for a maximum of six consecutive months.

# OFFICERS OF THE INSTITUTION

PATRON: H.M. THE QUEEN

## Council, 1960-61

**PRESIDENT**

SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C.*, LL.D., B.SC.

**PAST-PRESIDENTS**

W. H. ECCLES, D.SC., F.R.S.
THE RT. HON. THE EARL OF MOUNT EDGCUMBE, T.D.
J. M. DONALDSON, M.C.
PROF. E. W. MARCHANT, D.SC.
H. T. YOUNG
SIR GEORGE LEE, O.B.E., M.C.
J. R. BEARD, C.B.E., M.SC.
SIR NOEL ASHBRIDGE, B.SC.(ENG.)
SIR HARRY RAILING, D.ENG.
P. DUNSHEATH, C.B.E., M.A., D.SC.(ENG.), LL.D.
SIR VINCENT Z. DE FERRANTI, M.C.
T. G. N. HALDANE, M.A.
PROF. E. B. MOULLIN, M.A., SC.D., LL.D.
SIR ARCHIBALD J. GILL, B.SC.(ENG.)
SIR JOHN HACKING
COL. B. H. LEESON, C.B.E., T.D.
SIR HAROLD BISHOP, C.B.E., B.SC.(ENG.), F.C.G.I.
SIR JOSIAH ECCLES, C.B.E., D.SC.
THE RT. HON. THE LORD NELSON OF STAFFORD
SIR W. GORDON RADLEY, K.C.B., C.B.E., PH.D.(ENG.)
S. E. GOODALL, M.SC.(ENG.), F.Q.M.C.
SIR WILLIS JACKSON, D.SC., D.ENG., LL.D., F.R.S.

**VICE-PRESIDENTS**

B. DONKIN, B.A.
O. W. HUMPHREYS, C.B.E., B.SC.
G. S. C. LUCAS, O.B.E., F.C.G.I.
C. T. MELLING, C.B.E., M.SC.TECH.
A. H. MUMFORD, O.B.E., B.SC.(ENG.)

**HONORARY TREASURER**

C. E. STRONG, O.B.E., B.A., B.A.I.

**Ordinary Members of Council**

J. C. ARKLESS, B.SC.
PROF. H. E. M. BARLOW, PH.D., B.SC.(ENG.)
D. A. BARRON, M.SC.
C. O. BOYSE, B.SC.(ENG.)
F. H. S. BROWN, C.B.E., B.SC.
PROF. M. W. HUMPHREY DAVIES, M.SC.
SIR JOHN DEAN, B.SC.
L. DRUCQUER
J. M. FERGUSON, B.SC.(ENG.)
D. C. FLACK, B.SC.(ENG.), PH.D.
R. J. HALSEY, C.M.G., B.SC.(ENG.), F.C.G.I.
R. A. HORE, M.A., B.SC.
J. S. McCULLOCH
PROF. J. M. MEEK, D.ENG.
THE HON. H. G. NELSON, M.A.
H. V. PUGH
J. R. RYLANDS, M.SC., J.P.
R. L. SMITH-ROSE, C.B.E., D.SC., PH.D., F.C.G.I.
G. A. V. SOWTER, PH.D., B.SC.(ENG.)
H. G. TAYLOR, D.SC.(ENG.)
D. H. TOMPSETT, B.SC.(ENG.)

**Chairmen and Past-Chairmen of Sections**

*Electronics and Communications*
T. B. D. TERRONI, B.SC.
*M. J. L. PULLING, C.B.E., M.A.

*Measurement and Control*
C. G. GARTON
*PROF. A. TUSTIN, M.SC.

*Supply*
J. E. L. ROBINSON, M.SC.
*J. R. MORTLOCK, PH.D., B.SC.(ENG.)

*Utilization*
J. M. FERGUSON, B.SC.(ENG.)
*T. E. HOUGHTON, M.ENG.

**Chairmen and Past-Chairmen of Local Centres**

*East Midland*
LT.-COL. W. E. GILL, T.D.
*D. H. PARRY, B.SC.

*Mersey and North Wales*
D. A. PICKEN
*T. A. P. COLLEDGE, B.SC.(ENG.)

*North-Eastern*
D. H. THOMAS, M.SC.TECH., B.SC.(ENG.)
*H. WATSON-JONES, M.ENG.

*North Midland*
F. W. FLETCHER
*PROF. G. W. CARTER, M.A.

*North-Western*
F. LINLEY
*F. J. HUTCHINSON, M.ENG.

*Northern Ireland*
J. McA. IRONS
*T. S. WYLIE

*Scottish*
R. B. ANDERSON
*J. A. AKED, M.B.E.

*South Midland*
BRIG. F. JONES, C.B.E., M.SC.
*G. F. PEIRSON

*Southern*
R. GOFORD
*W. D. MALLINSON, B.SC.(ENG.)

*Western*
A. C. THIRTLE
*H. JACKSON, B.SC.(ENG.)

* *Past-Chairman*

| | |
|---|---|
| **SECRETARY** | W. K. BRASHER, C.B.E., M.A., M.I.E.E. |
| **Deputy Secretary** | F. JERVIS SMITH, M.I.E.E. |
| **Principal Assistant Secretary** | F. C. HARRIS |
| **Assistant Secretary** | N. C. STAMFORD, M.SC.TECH., M.I.E.E. |
| **Chief Accountant** | F. H. JOB, F.A.C.C.A., A.C.I.S. |
| **Editor-in-Chief** | G. E. WILLIAMS, B.SC.(ENG.), M.I.E.E. |
| **Editor, *Journal*** | W. G. ASKEW, M.C. |
| **Editor, *Science Abstracts*** | B. M. CROWTHER, M.A., PH.D. |

# Local Centre Officers

## EAST MIDLAND CENTRE

*Chairman:* LT.-COL. W. E. GILL, T.D.

*Hon. Secretary:* W. L. PASSANT, 49 Toller Road, Quorn, Loughborough, Leics.

*Hon. Asst. Secretary:* J. BARNES, D.L.C., Asst. Engineer, Overhead Lines Transmission Dept., Central Electricity Generating Board, Nottingham

### Cambridge Electronics and Measurement Group

*Chairman:* H. V. BECK, M.A., B.SC.

*Hon. Secretary:* R. BARRASS, c/o Pye Ltd., St. Andrew's Road, Cambridge

### East Anglian Sub-Centre

*Chairman:* E. A. FOWLER

*Hon. Secretary:* CAPT. N. HILLER, B.SC.(ENG.), Cambridgeshire Technical College and School of Art, Collier Road, Cambridge

*Hon. Asst. Secretary:* J. W. HUGHES, B.SC.(ENG.), 74 Hurst Park Avenue, Cambridge

## MERSEY AND NORTH WALES CENTRE

*Chairman:* D. A. PICKEN

*Hon. Secretary:* G. SHEPHERD, 31 Rutherford Road, Windle, St. Helens, Lancs.

*Hon. Asst. Secretaries:* C. E. R. FAIRBURN, M.A., c/o English Electric Co. Ltd., Liverpool Works, East Lancashire Road, Liverpool 10; J. N. FLETCHER, B.SC., PH.D., Brookhirst Switchgear Ltd., Northgate Works, Chester; B. F. TICKLE, 13 Auckland Grove, Nutgrove, St. Helens, Lancs.

## NORTH-EASTERN CENTRE

*Chairman:* D. H. THOMAS, M.SC.TECH., B.SC.(ENG.)

*Joint Hon. Secretaries:* R. BRUCE, M.SC., C. A. Parsons and Co. Ltd., Heaton Works, Newcastle upon Tyne 6; E. A. SIMS, North Eastern Electricity Board, Carliol House, Newcastle upon Tyne 1

*Asst. Secretary:* R. W. SHIELD, 152 Edge Hill, Darras Hall, Ponteland, Newcastle upon Tyne

### North-Eastern Measurement and Electronics Group

*Chairman:* E. D. TAYLOR, M.SC.

*Hon. Secretary:* R. BRUCE, M.SC., C. A. Parsons and Co. Ltd., Heaton Works, Newcastle upon Tyne 6

### Tees-Side Sub-Centre

*Chairman:* T. W. J. TEMPLE

*Hon. Secretary:* D. W. PATTENDEN, 45 Stanhope Grove, Acklam, Middlesbrough

## NORTH MIDLAND CENTRE

*Chairman:* F. W. FLETCHER

*Hon. Secretary:* J. WOODHOUSE, c/o Brush Electrical Engineering Co. Ltd., Scottish Union Building, 26 Park Row, Leeds 1

*Hon. Asst. Secretary:* J. N. B. GRIFFITHS, 48 Cornwall Road, Harrogate, Yorks.

### North Midland Utilization Group

*Chairman:* W. PATERSON, B.SC.

*Hon. Secretary:* H. J. TOWSE, B.SC.(ENG.), c/o English Electric Co. Ltd., Traction Control Design Dept., Bradford 3

### Sheffield Sub-Centre

*Chairman:* E. J. LILLEKER

*Hon. Secretary:* J. E. CALDWELL, B.SC.(ENG.), 5 Cockshutt Road, Beauchief, Sheffield 8

*Hon. Asst. Secretary:* J. E. LEESON, 56 Vernon Road, Totley, Sheffield

## NORTH-WESTERN CENTRE

*Chairman:* F. LINLEY

*Hon. Secretary:* H. DIGGLE, B.SC.TECH., Associated Electrical Industries Ltd., Transformer Division, Southmoor Road, Wythenshawe, Manchester 23

### North-Western Measurement and Control Group

*Chairman:* A. CHORLTON, B.SC.TECH.

*Hon. Secretary:* R. W. FRYER, 2 Rossett Avenue, Timperley, Altrincham, Cheshire

### North-Western Electronics and Communications Group

*Chairman:* C. HEYS

*Hon. Secretary:* J. DALTON, 12 Cedar Avenue, Claypool Road, Horwich, Lancs.

### North-Western Supply Group

*Chairman:* J. B. KILSHAW

*Hon. Secretary:* F. W. TAYLOR, M.SC.TECH., 211 Chamber Road, Oldham, Lancs.

### North-Western Utilization Group

*Chairman:* C. AYRES, B.SC.(ENG.)

*Hon. Secretary:* W. F. JARVIS, 8 Fairview Road, Timperley, Cheshire

### North Lancashire Sub-Centre

*Chairman:* C. C. BACON

*Hon. Secretary:* F. DAY, c/o North Western Electricity Board, 40/41 Lune Street, Preston

*Hon. Asst. Secretary and Treasurer:* A. BARTLETT, 99 Black Bull Lane, Fulwood, Preston

## NORTHERN IRELAND CENTRE

*Chairman:* J. MCA. IRONS

*Hon. Secretary:* R. L. MARRS, B.SC., Gallaher Ltd., Virginia House, York Street, Belfast 15

*Hon. Asst. Secretary:* W. H. FARMER, Room 49, Telephone House, 1 Cromac Street, Belfast

## SCOTTISH CENTRE

*Chairman:* R. B. ANDERSON

*Hon. Secretary and Treasurer:* D. R. ROLLO, B.SC.(ENG.), Bruce Peebles and Co. Ltd., 26 Blythswood Square, Glasgow C.2

### North Scotland Sub-Centre

*Chairman:* L. F. DORWARD, B.SC.

*Hon. Secretary:* K. J. MCCONNELL, c/o Jute Industries Ltd., Engineering Dept., Tay Carpet Works, Lochee Road, Dundee

*Hon. Asst. Secretary:* J. C. EARLS, B.SC.(ENG.), c/o Electrical Engineering Dept., Robert Gordon's Technical College, Aberdeen

### South-East Scotland Sub-Centre

*Chairman:* I. S. FRASER, B.SC.

*Hon. Secretary and Treasurer:* C. M. BECKETT, T.D., M.A., c/o Bruce Peebles and Co. Ltd., E. Pilton, Edinburgh 5

### South-West Scotland Sub-Centre

*Chairman:* W. L. KIDD, B.SC.TECH.

*Hon. Secretary and Treasurer:* D. W. GREGORY, c/o Johnson and Phillips Ltd., 59 Berkeley Street, Glasgow C.3

## SOUTH MIDLAND CENTRE

*Chairman:* BRIGADIER F. JONES, C.B.E., M.SC.

*Hon. Secretary:* J. C. PYATT, c/o Central Electricity Generating Board, Nechells 'B' Power Station, Nechells, Birmingham 7

*Hon. Asst. Secretary:* E. H. COX, Midlands Electricity Board, Mucklow Hill, Halesowen, Birmingham

### South Midland Electronics and Measurement Group

*Chairman:* H. M. GALE, B.SC.(ENG.)

*Hon. Secretary:* E. S. JOHNSON, c/o Telephone Manager, 63 Hagley Road West Birmingham 17

### South Midland Supply and Utilization Group

*Chairman:* H. M. FRICKE, B.SC.

*Hon. Secretary:* H. C. FOX, 12 Carnwath Road, Sutton Coldfield, Warwicks.

### North Staffordshire Sub-Centre

*Chairman:* G. H. GILLAM

*Hon. Secretary:* P. W. R. GATLIFF, B.SC., English Electric Co. Ltd., Stafford

*Hon. Asst. Secretaries:* A. P. BAINES, 51 Springfield Drive, Mosspitt, Stafford; (*Stoke*) N. M. MORRIS, 62 Maythorne Road, Blurton, Stoke on Trent; (*Crewe*) M. M. MACMASTER, B.SC., Crewe Further Education Sub-Committee, Technical College, Hightown, Crewe; (*Stone*) C. E. WOOLLEY, 26 Raleigh Hall, Eccleshall, Staffs.

### Rugby Sub-Centre

*Chairman:* E. S. HALL

*Hon. Secretary:* J. RICHMOND, M.B.E., B.ENG., 53 Vernon Avenue, Rugby

*Hon. Asst. Secretaries:* R. W. ROBINSON, 51 Yates Avenue, Newbold Glebe, Rugby; A. J. GILBERT, B.A., Associated Electrical Industries Ltd., Heavy Plant Division, Rugby

## SOUTHERN CENTRE

*Chairman:* R. GOFORD

*Hon. Secretary:* H. W. HOUSLEY, 15 Southdown Road, East Cosham, Portsmouth, Hants

*Hon. Asst. Secretaries:* A. C. TREMAIN, B.SC.(ENG.), Municipal College, Portsmouth, Hants; C. G. BRAMMER, 48 Brecon Avenue, East Cosham, Hants; H. V HARLEY, B.SC., 72 Maylands Road, Bedhampton, Havant, Hants

## WESTERN CENTRE

*Chairman:* A. C. THIRTLE

*Hon. Secretary:* D. STEPHENS, 7 Clovelly Crescent, Llanrumney, Cardiff

*Hon. Asst. Secretaries:* (*Bristol*) W. D. MORGAN, 'Green Lea', Farleigh, Backwell, nr. Bristol; (*Cardiff*) W. REAL, 14 Manor Rise, Whitchurch, Cardiff

### Western Supply Group

*Chairman:* A. H. MCQUEEN

*Hon. Secretary:* R. ALDERSON, South Wales Switchgear Ltd., Blackwood, Mon.

### Western Utilization Group

*Chairman:* E. HAWKESLEY

*Hon. Secretary:* W. S. EVANS, Broad Oak, 3 Heol Wen, Rhiwbina, Cardiff

*Hon. Asst. Secretary:* A. R. S. GOUGH, 'Greenacres', Hempton Lane, Almondsbury, Bristol

## Local Centre Officers (continued)

**South-Western Sub-Centre**
*Chairman:* F. C. ISAAC
*Hon. Secretary:* G. T. FERRIS, Superintendent, Plymouth 'A' Generating Station, Prince Rock, Plymouth, Devon
*Hon. Asst. Secretary:* R. R. ROBINSON, 23 Chestwood Avenue, Oakland Park, Barnstaple, Devon

**West Wales (Swansea) Sub-Centre**
*Chairman:* J. NELSEY, B.SC.(ENG.)
*Hon. Secretary:* C. EVANS, 38 Old Road, Llanelly, Carmarthenshire
*Hon. Asst. Secretary:* D. H. HUGHES, 5 Hillside, Furnace, Llanelly, Carmarthenshire

# Oversea Representatives of the Council

**ARGENTINA**
B. G. BORISSOW, B.SC.(ENG.), c/o Metropolitan-Vickers Export Co. Ltd., Avda. Roque Saenz Pena 636, 7° Piso, Buenos Aires

**BRAZIL**
E. WINSTANLEY, B.SC.(ENG.), Rio de Janeiro Flour Mills and Granaries Ltd., Caixa Postal 486, Rio de Janeiro

**BURMA**
C. H. MELLOR, c/o Rangoon Electric Supply Board, 503/9 Merchant Street, Rangoon

**CANADA**
J. M. THOMSON, M.A.SC., PH.D., Ferranti-Packard Electric Ltd., Industry Street, Toronto 15, Ontario
(*Alberta*) PROF. J. A. HARLE, M.SC., Head of Department of Electrical Engineering, University of Alberta, Edmonton; (*British Columbia*) DEAN D. M. MYERS, D.SC.(ENG.), B.SC., B.E., c/o Faculty of Applied Science, University of British Columbia, Vancouver 8; (*Ontario*) R. P. HORLOCK, B.SC.(ENG.), Associated Electrical Industries (Canada) Ltd., 212 King Street West, Toronto 1; (*Quebec*) F. L. LAWTON, B.A.SC., c/o Aluminium Laboratories Ltd., 1800 Sun Life Building, Montreal

**CAPE PROVINCE**
C. G. DOWNIE, B.SC., c/o City Electricity Dept., P.O. Box 82, Cape Town

**CEYLON**
(*Acting*) D. P. BENNETT, c/o Walker Sons and Co. Ltd., Colombo

**EAST AFRICA**
A. O. COSGROVE, B.SC., General Electric Co. Ltd., P.O. Box 5100, Nairobi
Deputy Representatives: (*Uganda*) J. M. STOCK, O.B.E., M.ENG., Uganda Electricity Board, Kampala; (*Tanganyika*) J. H. GRIFFITHS, c/o Public Works Dept. Headquarters, Dar es Salaam, Tanganyika

**FAR EAST**
D. S. HILL, Reiss, Bradley and Co. Ltd., National City Bank of New York Building, 2 Queen's Road C, Hong Kong

**FRANCE**
P. M. J. AILLERET, Électricité de France, 12 Place des États-Unis, Paris (16e)
Deputy Representative; R. A. TELLIER, ING.É.S.É., c/o Électricité de France, 12 Place des États-Unis, Paris (16e)

**GHANA**
E. M. KORAM, B.SC.(ENG.), Posts and Telecommunications, Accra, Ghana

**INDIA**
F. WADE-COOPER, Magnet House, Chittaranjan Avenue, P.O. Box 8974, Calcutta 13
Deputy Representatives: L. W. BRAZEL, Calcutta Electric Supply Corporation Ltd., Victoria House, Calcutta
(*Bombay*) J. H. SMYTHE, B.SC., Greaves, Cotton and Crompton Parkinson Ltd., 1 Forbes Street; (*Delhi*) SHIV NARAYAN, SC.D., M.SC., B.E., M.A., B.SC., 2547 Nai Wara, 6; (*Madras*) J. MEEK, B.SC.(ENG.), c/o General Electric Co. (India) Ltd., Magnet House, Mount Road, P.O. Box 351

**ISRAEL**
B. F. MOSS, 94 Hayarkon Street, Tel Aviv

**MALAYA AND SINGAPORE**
W. TRAFFORD, M.B.E., c/o William Jacks and Co. (M) Ltd., P.O. Box 286, Eastern Bank Building, No. 2 Embankment, Kuala Lumpur, Malaya
Deputy Representative: F. R. WARDROP, B.SC.(ENG.), Central Electricity Board, P.O. Box 1003, Kuala Lumpur, Malaya

**NATAL**
R. M. O. SIMPSON, c/o Electricity Dept., P.O. Box 147, Durban

**MIDDLE EAST**
H. D. FURBER, D.F.H., c/o Iraq Petroleum Co. Ltd., Sharia Al Mansour, Baghdad, Iraq
Deputy Representative: J. D. ADDISON, M.B.E., P.O. Box 54, Kuwait, Arabia

**NEAR EAST**
PROF. R. W. SLOANE, M.A., PH.D., B.SC., Director of the Engineering Experimental and Service Laboratories, American University of Beirut, Beirut, Lebanese Republic

**NEW SOUTH WALES**
J. T. ROLLO, I.E.E. Box 701, G.P.O., Sydney (telephone Sydney B0323, ext. 313)

**NEW ZEALAND**
G. R. MILNE, B.SC., P.O. Box 749, Wellington C.1

**PAKISTAN**
H. L. JEFFERIES, c/o Pakistan Cables Ltd., P.O. Box 5050, Karachi

**QUEENSLAND**
J. S. JUST, 14 Dickson Terrace, Hamilton, N.E.2, Brisbane

**RHODESIA**
A. B. COWEN, O.B.E., P.O. Box 377, Salisbury

**SOUTH AUSTRALIA**
G. H. MACHIN, B.E., c/o Electricity Trust of South Australia, Box 412C, G.P.O., Adelaide

**SWITZERLAND**
L. W. HAYES, O.B.E., 43 Quai Wilson, Geneva

**TRANSVAAL AND ORANGE FREE STATE**
A. W. LINEKER, B.SC., P.O. Box 7794, Johannesburg

**UNITED STATES OF AMERICA**
*Hon. Secretary:* G. H. O'SULLIVAN, B.E., E.E., J. G. White Engineering Corporation, 80 Broad Street, New York 4, N.Y.

**VICTORIA AND TASMANIA**
PROF. C. E. MOORHOUSE, M.E.E., Department of Electrical Engineering, University of Melbourne, Carlton N.3, Victoria
Deputy Representative for Tasmania: H. P. TUCK, M.E., B.SC., Associate Professor, University of Tasmania, Hobart, Tasmania

**WEST AFRICA**
J. HOUSTON ANGUS, Private Mail Bag 2031, Lagos, Nigeria

**WEST INDIES**
H. D. WALDEN, B.SC., Texaco Trinidad Inc., 6 Bon Accord Road, Point-à-Pierre Trinidad

**WESTERN AUSTRALIA**
J. B. JUKES, B.E., State Electricity Commission of Western Australia, Electricity House, 321 Murray Street, Perth

# Oversea Branches

**BOMBAY BRANCH**
*Chairman:* J. C. PATEL, B.SC.
*Hon. Secretary:* T. M. SHIVRAM, c/o Greaves, Cotton and Crompton Parkinson Ltd., 1 Forbes Street, Post Fort, Bombay 1

**CALCUTTA BRANCH**
*Chairman:* A. K. BHAUMIK, B.SC.(ENG.)
*Hon. Secretary:* L. W. BRAZEL, Calcutta Electric Supply Corporation Ltd., Victoria House, Calcutta

**CEYLON BRANCH**
*Chairman:* E. C. FERNANDO, M.B.E., B.SC.(ENG.)
*Hon. Secretary:* S. W. PEIRIS, B.SC.(ENG.), P.O. Box 540, Colombo

**IRISH BRANCH**
*Chairman:* C. V. O'DONNELL, M.E.
*Hon. Secretary:* J. MCKEEVER, B.SC.(ENG.), General Electric Co. Ltd., Magnet House, Adelaide Road, Dublin
*Hon. Asst. Secretary:* C. A. MCLOUGHLIN, B.SC., c/o Electricity Supply Board, 21 Lower Fitzwilliam Street, Dublin

# Oversea Committees

**AUSTRALIA**

**New South Wales**
*Chairman:* H. B. WOOD, B.SC., M.E.
*Hon. Secretary:* D. K. MUIR, I.E.E. Box 701, G.P.O., Sydney

**Queensland**
*Chairman:* A. S. FAULKNER
*Hon. Secretary:* W. I. GEORGE, B.E., 124 Seventh Avenue, St. Lucia, Brisbane

**South Australia**
*Chairman:* F. R. HILL, B.SC.
*Hon. Secretary:* S. LECHOWICZ, 52 Park Road, Kensington Park, Adelaide

**Victoria and Tasmania**
*Chairman:* J. WILSON
*Hon. Secretary:* D. P. DAVIES, M.SC., Pen Bryn, Mt. Macedon, Victoria

**Western Australia**
*Chairman:* K. W. TAPLIN, B.E.
*Hon. Secretary and Treasurer:* R. R. LAKE, B.E., c/o 132 Murray Street, Perth

**CANADA**
**Toronto**
*Chairman:* THE OVERSEA REPRESENTATIVE OF THE COUNCIL

**INDIA**
**Madras**
*Chairman:* N. C. S. KUMAR, B.SC.
*Hon. Secretary:* E. H. BRAZEL, Binny and Co. Ltd. (Madras), Engineering Dept., P.O. Box No. 66, Madras

**MALAYA AND SINGAPORE**
*Chairman:* THE OVERSEA REPRESENTATIVE OF THE COUNCIL

**NEW ZEALAND**
*Chairman:* F. T. M. KISSEL, I.S.O., B.SC.
*Hon. Secretary:* G. R. MILNE, B.SC., P.O. Box 749, Wellington C.1

**SOUTH AFRICA**
**Transvaal and Orange Free State**
*Chairman:* THE OVERSEA REPRESENTATIVE OF THE COUNCIL

## Joint Groups

**ADEN**
*Chairman:* G. A. MALONE, A.M.I.MECH.E.
*Hon. Secretary:* J. D. D. DAVIES, B.SC., A.M.I.E.E., 13786 Projects Electrical Engineer, c/o B.P. Refinery (Aden) Ltd., P.O. Box 3003, Aden, Arabia

**ARGENTINA**
*Chairman:* H. Y. BUCHANAN, A.M.I.C.E.
*Hon. Secretary and Treasurer:* J. COMBES, A.M.I.C.E., c/o Percy Grant and Co., Calle Defensa 465, Buenos Aires

**BRITISH GUIANA**
*Chairman:* R. F. CAMACHO, M.I.C.E.
*Hon. Secretary:* D. S. FAIRBAIRN, A.M.I.C.E., Drainage and Irrigation Department, P.O. Box 26, Georgetown

**GHANA**
*Chairman:* W. O. DAVIES, M.I.C.E.
*Hon. Secretary:* C. D. WILKINSON, A.M.I.C.E., Telecommunications Engineering School, Accra

**HONG KONG**
*Chairman:* G. B. GIFFORD-HULL, M.I.C.E.
*Hon. Secretary and Treasurer:* L. F. ROBERTS, B.SC., M.I.E.E., c/o British General Electric Co. Ltd., Queen's Buildings, Chater Road

**JAMAICA**
*Chairman:* O. M. HENZELL, M.I.MECH.E.
*Hon. Secretary:* B. G. SINGH, M.SC., PH.D., A.M.I.C.E., P.O. Box 45, Kingston 10

**SINGAPORE/MALAYA**
*Chairman:* C. M. CALDER, M.I.MECH.E.
*Hon. Secretary:* I. M. VARLEY, B.SC., A.M.I.C.E., Shell Co. of Singapore Ltd., P.O. Box 730, Shell House, Collyer Quay, Singapore

## Professional Groups

**GIBRALTAR**
*Chairman:* E. V. ANDLAW, M.B.E., M.I.MECH.E., M.I.E.E.
*Hon. Secretary:* MAJ. D. S. EVANS, A.M.I.MECH.E., R.E.M.E., 51 Europa Road

**MIDDLE EAST**
*Chairman:* M. MOHTADI, B.SC., A.M.I.E.E.
*Hon. Secretary:* D. W. PLATT, B.SC.(ENG.), A.M.I.MECH.E., A.M.I.E.E., c/o Kuwait Oil Co. Ltd., Ahmadi, Kuwait. Arabia

**TRINIDAD AND TOBAGO**
*Chairman:* K. W. FINCH, M.I.E.E.
*Hon. Secretary:* D. P. J. HOLBROOK, B.SC.(ENG.), A.M.I.E.E., c/o Trinidad Oilfield Service Ltd., P.O. Box 69, San Fernando, Trinidad

**WEST AFRICA**
*Chairman:* R. K. INNES, M.I.C.E.
*Hon. Secretary:* D. DAVIS, M.ENG., A.M.I.E.E., Private Mail Bag 2363, Lagos, Nigeria

## Graduate and Student Sections

**BRISTOL**
*Chairman:* P. D. GOODENOUGH
*Hon. Secretary:* H. ROPER, Westinghouse Brake and Signal Co. Ltd., Chippenham, Wilts.

**CARDIFF**
*Chairman:* A. W. HART
*Hon. Secretary:* J. L. BRACE, 64 Melrose Avenue, Penylan, Cardiff

**EAST MIDLAND**
*Chairman:* D. G. WALTERS, B.SC.(ENG.)
*Hon. Secretary:* I. W. ROBINSON, B.SC., 99 Toothill Road, Loughborough

**IRISH BRANCH**
*Chairman:* K. G. EGAR
*Hon. Secretary:* A. J. DUFFY, 32 Upper Baggot Street, Dublin

**LONDON**
*Chairman:* A. PORTER
*Hon. Secretary:* F. P. HARWOOD, Dale Cottage, Holmbury St. Mary, Dorking, Surrey

**MERSEY AND NORTH WALES**
*Chairman:* A. J. IVESON
*Hon. Secretary:* D. G. ROBINSON, 6 Thirlmere Street, Wallasey, Cheshire

**NORTH-EASTERN**
*Chairman:* R. HAWLEY, B.SC.
*Hon. Secretary:* A. C. HALL, Transformer Design Dept., C. A. Parsons and Co. Ltd., Heaton Works, Newcastle upon Tyne 6

**NORTH MIDLAND**
*Chairman:* D. B. WARDMAN
*Hon. Secretary:* C. H. STACEY, 89 Altofts Lodge Drive, Normanton, Yorks.

**NORTH SCOTLAND**
*Chairman:* U. E. O. UCHENYI
*Hon. Secretary:* J. MOWAT, The Manse of Newhills, Bucksburn, Aberdeen

**NORTH STAFFORDSHIRE**
*Chairman:* D. J. ANDREWS, B.SC.
*Hon. Secretary:* R. E. BEADLE, Metal Industries Engineers, English Electric Co. Ltd., Stafford

**NORTH-WESTERN**
*Chairman:* D. F. BINNS, M.SC.
*Hon. Secretary:* D. L. K. BOWERS, c/o Associated Electrical Industries Ltd., Power Section, Industrial Machines Dept. Sales, Mosley Road Works, Manchester 17

**NORTHERN IRELAND**
*Chairman:* H. MCKILLEN
*Hon. Secretary:* J. B. HARSON, B.SC., c/o Electricity Board for Northern Ireland, 23–27 Ballymoney Street, Ballymena, Co. Antrim

**RUGBY**
*Chairman:* T. J. ROBERTS, B.SC.
*Hon. Secretary:* E. I. FLEURET, Medium Electrical Machine Sales, A.E.I. Heavy Plant Division, Rugby

**SHEFFIELD**
*Chairman:* J. ALLISON, B.SC.(ENG.), PH.D.
*Hon. Secretary:* P. A. MCINNES, B.ENG., Electrical Engineering Dept., The University, Mappin Street, Sheffield 1

**SOUTH-EAST SCOTLAND**
*Chairman:* K. VON KROGH, A.H.-W.C.
*Hon. Secretary:* G. J. H. BROOKING, A.R.C.S.T., c/o Bruce Peebles and Co. Ltd., 37 Inverleith Place, Edinburgh 3

**SOUTH MIDLAND**
*Chairman:* K. GUNARY, D.F.H.
*Hon. Secretary:* M. V. BRADBURY, DIP.TECH.(ENG.), 9 Chestnut Close, Norton Stourbridge, Worcs.

**SOUTH-WEST SCOTLAND**
*Chairman:* P. L. V. POMELLA, B.SC.
*Hon. Secretary:* D. RAESIDE, B.SC., c/o Dept. of Electrical Engineering, College of Science and Technology, Glasgow C.1

**SOUTHERN**
*Chairman:* R. E. HAYES, M.SC., PH.D.
*Hon. Secretary:* S. A. FRAMPTON, 36 Ibsley Grove, Bedhampton, Hants

**TEES-SIDE**
*Chairman:* K. S. MILLINGTON
*Hon. Secretary:* R. M. EPPS, 20 Coniston Grove, Acklam, Middlesbrough

## Local Honorary Treasurers of the Benevolent Fund

| | |
|---|---|
| East Midland Centre | *L. Adlington* |
| Irish Branch | *A. Harkin, M.E.* |
| Mersey and North Wales Centre | *D. A. Picken* |
| North-Eastern Centre | *J. F. Skipsey, B.Sc.* |
| Tees-Side Sub-Centre | *W. K. Harrison* |
| North Midland Centre | *E. C. Walton, Ph.D., B.Eng.* |
| Sheffield Sub-Centre | *F. Seddon* |
| North-Western Centre | *E. G. Taylor, B.Sc.(Eng.)* |
| North Lancashire Sub-Centre | *H. Charnley* |
| Northern Ireland Centre | *G. H. Moir, J.P.* |
| Scottish Centre | *R. H. Dean, B.Sc.Tech.* |
| North Scotland Sub-Centre | *P. Philip* |
| South Midland Centre | *H. M. Fricke* |
| Rugby Sub-Centre | *P. G. Ross, B.Sc.* |
| Southern Centre | *J. E. Brunnen* |
| Western Centre (Bristol) | *A. H. McQueen* |
| Western Centre (Cardiff) | *E. W. S. Watt* |
| West Wales (Swansea) Sub-Centre | *O. J. Mayo* |
| South-Western Sub-Centre | *W. E. Johnson* |

# Representatives of The Institution on other bodies

The following is a list of representatives of The Institution on other bodies with the dates on which they were appointed

**Advisory Council on Education for Management**
Col. B. H. Leeson, C.B.F., T.D. (1.12.60)

**Association of Supervising Electrical Engineers**
EDUCATION AND TRAINING COMMITTEE
B. L. Metcalf, B.SC.(ENG.) (8.10.53)

**Battersea College of Technology**
ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING
F. J. Lane, O.B.E., M.SC. (26.6.58)

**Birmingham College of Advanced Technology**
ADVISORY COMMITTEE FOR ENGINEERING
G. F. Peirson (26.6.58)

**Birmingham Technical Colleges**
ELECTRICAL ENGINEERING ADVISORY COMMITTEE
L. L. Tolley, B.SC.(ENG.) (23.6.60)

**Blackburn Technical College**
ENGINEERING ADVISORY COMMITTEE
H. Shackleton, M.SC. (6.12.56)

**Bolton Technical College**
ENGINEERING TRADES ADVISORY SUB-COMMITTEE
H. Diggle, B.SC.TECH. (12.9.57)

**Bootle Municipal Technical College**
GOVERNING BODY
J. Collins (17.5.56)

**Bournemouth Municipal College of Technology and Commerce**
ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING
W. M. Read (3.12.59)

**Bradford Institute of Technology**
GOVERNING BODY
A. J. Coveney (27.6.57)
ADVISORY COMMITTEE ON ELECTRICAL ENGINEERING
A. J. Coveney (17.9.59)

**Brighton Technical College**
ENGINEERING ADVISORY COMMITTEE
W. E. Gibbs (3.11.55)

**Bristol College of Technology**
BOARD OF GOVERNORS
Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C.*, LL.D., B.SC. (26.6.58)

**Bristol University**
COURT OF THE UNIVERSITY
A. N. Irens (6.11.58)
ENGINEERING ADVISORY COMMITTEE
A. G. Milne (25.6.59)

**British Association for Commercial and Industrial Education**
The Chairman of the Education and Training Committee (26.4.56)
The Secretary of The Institution (26.4.56)

**British Conference on Automation and Computation**
COUNCIL
W. Bamford, B.SC. (15.9.60)
J. F. Coales, O.B.E., M.A. (15.9.60)

**British Council**
ENGINEERING ADVISORY PANEL
The Secretary of The Institution (or his deputy) (2.12.48)
SCIENCE ADVISORY COMMITTEE
Sir Harold Bishop, C.B.E., B.SC.(ENG.) (6.2.58)

**British Electrical and Allied Industries Research Association**
COUNCIL
Prof. J. Greig, M.SC., PH.D. (7.12.50)
A. W. Montgomery, O.B.E., B.SC.TECH. (6.3.52)
SECTIONAL COMMITTEE ON UNCLASSIFIED RESEARCHES
Sir Harry Railing, D.ENG. (8.1.31)
SUB-COMMITTEE ON EARTHING AND EARTH PLATES
*Appointment pending*
SUB-COMMITTEE ON RADIO INTERFERENCE
F. Jervis Smith (19.10.45); W. J. Bray, M.SC. (11.9.58)

**British Electrical Development Association**
SUB-COMMITTEE ON THE INSTALLATION OF STORAGE BLOCK HEATERS
R. A. Marryat, B.SC.(ENG.) (10.1.57)

**British Electrical Power Convention**
COUNCIL
B. L. Metcalf, B.SC.(ENG.) (6.3.58)
(Deputy, the Secretary of The Institution—5.2.53)

**British National Committee for Non-Destructive Testing**
C. G. Garton (9.1.58)

**British National Committee on Documentation**
The Secretary of The Institution (or his deputy) (1.4.48)
B. M. Crowther, M.A., PH.D. (1.4.48)

**British Nuclear Energy Conference**
BOARD
F. H. S. Brown, C.B.E., B.SC. (15.9.60)
Sir Willis Jackson, D.SC., F.R.S. (31.3.55)

**British Standards Institution**
ENGINEERING DIVISIONAL COUNCIL (E/–)
Sir Josiah Eccles, C.B.E., D.SC. (3.3.55); Sir Archibald J. Gill, B.SC.(ENG.) (2.4.59); Sir John Hacking (7.3.57)
DATA PROCESSING INDUSTRY STANDARDS COMMITTEE (DPE/–)
H. M. Ross, M.A. (15.9.60)
NUCLEAR ENERGY INDUSTRY STANDARDS COMMITTEE
H. West, M.SC. (6.10.60)
ELECTRICAL INDUSTRY STANDARDS COMMITTEE (ELE/–)
The President of The Institution (*ex officio*) (7.3.46)
W. K. Brasher, C.B.E., M.A. (27.6.40)
P. Dunsheath, C.B.E., M.A., D.SC.(ENG.) (9.5.46)
Sir Vincent Z. de Ferranti, M.C. (3.2.49); Sir John Hacking (7.12.50); Forbes Jackson (3.11.60); G. O. Watson (22.6.44) (Representing the Ship Electrical Equipment Committee)
SUB-COMMITTEE ON MARINE MOTORS AND GENERATORS (ELE/1/10)
H. B. Hughes, B.SC. (5.3.59)
H. R. Ogle (8.1.59)
G. O. Watson (20.9.46)
TECHNICAL COMMITTEE ON VOLTAGES, CURRENT RATINGS, AND FREQUENCIES (ELE/2)
J. L. Miller, D.ENG., PH.D. (1.3.45)
TECHNICAL COMMITTEE ON ELECTRIC CABLES (ELE/3)
H. B. Hughes, B.SC. (11.9.58); *C. E. Mills (6.12.51)
G. O. Watson (31.12.36)
WORKING PARTY FOR COMMONWEALTH CONFERENCE ON CABLES (ELE/3/–/2)
B. Donkin, B.A. (6.12.56)
SUB-COMMITTEE ON SHIPS' CABLES (ELE/3/2)
E. E. Hutchings, B.SC.(ENG.) (5.3.59); *C. E. Mills (6.12.51)
G. O. Watson (20.10.38)
SUB-COMMITTEE ON RUBBER-INSULATED CABLES (ELE/3/7)
*B. Donkin, B.A. (2.2.50); *C. E. Mills (15.9.49)
SUB-COMMITTEE ON P.V.C.-INSULATED CABLES (ELE/3/8)
*B. Donkin, B.A. (30.3.50); *C. E. Mills (15.9.49)
SUB-COMMITTEE ON PAPER-INSULATED CABLES (ELE/3/10)
J. W. Leach (13.9.51)
SUB-COMMITTEE ON POLYTHENE-INSULATED CABLES (ELE/3/11)
B. Donkin, B.A. (3.4.52); C. E. Mills (3.4.52)
SUB-COMMITTEE ON VARNISHED-CAMBRIC INSULATED CABLES (ELE/3/15)
J. W. Leach (5.11.53)
SUB-COMMITTEE ON P.V.C. CABLES FOR SWITCHBOARDS (ELE/3/17)
The Secretary of The Institution (or his deputy) (1.12.60)
SUB-COMMITTEE ON MINERAL-INSULATED CABLES (ELE/3/18)
*J. S. McCulloch (26.4.56)
SUB-COMMITTEE ON FITTINGS FOR MINERAL-INSULATED CABLES (ELE/3/19)
*J. S. McCulloch (12.9.57)
SUB-COMMITTEE ON POLYTHENE INSULATION AND SHEATH (ELE/3/20)
C. E. Mills (6.2.58)
SUB-COMMITTEE ON HEAT-RESISTING CABLES (ELE/3/21)
*C. E. Mills (6.3.58)
SUB-COMMITTEE FOR LIFTS ELE/3/24)
C. E. Mills (12.9.57)
COMMITTEE ON ARMOURED P.V.C.-INSULATED CABLES (ELE/3/25)
T. A. Frazer, M.A. (14.5.59)
SUB-COMMITTEE ON THE CO-ORDINATION OF C.E.E. WORK ON CABLES (ELE/3/27)
B. Donkin, B.A. (11.9.58)
SUB-COMMITTEE ON FLEXIBLE CORDS FOR PORTABLE APPLIANCES (ELE/3/28)
R. A. Marryat, B.SC.(ENG.) (19.5.60)
TECHNICAL COMMITTEE ON ELECTRICAL ACCESSORIES (ELE/4)
* T. A. Frazer, M.A. (6.10.60); *S. L. M. Barlow (26.4.56)

* Appointed for liaison with the Wiring Regulations Committee

SUB-COMMITTEE ON TUMBLER SWITCHES (ELE/4/1)
J. I. Bernard, B.SC.TECH. (17.5.51); *E. J. Sutton (12.5.49)

SUB-COMMITTEE ON WALL-PLUGS AND SOCKETS (ELE/4/2)
*H. G. Gamble (3.4.52); J. Hall, B.SC.(ENG.) (19.6.52)
*E. J. Sutton (12.5.49)

SUB-COMMITTEE ON FUSES (ELE/4/3)
*B. Donkin, B.A. (12.5.49); *F. H. Mann (17.5.51)
*E. J. Sutton (6.12.51); G. O. Watson (23.2.39)

SUB-COMMITTEE ON CEILING ROSES (ELE/4/7)
*E. J. Sutton (12.5.49)

SUB-COMMITTEE ON CONNECTORS FOR PORTABLE APPLIANCES (ELE/4/10)
*H. G. F. Lambe (11.9.58); L. A. Corney, B.SC.(ENG.) (17.9.59)

SUB-COMMITTEE ON PROTECTED-TYPE PLUGS AND SOCKETS (FOR INDUSTRIAL PURPOSES) (ELE/4/11)
S. J. Emerson, M.ENG. (15.5.52); *C. E. Mills (3.4.52)
*E. J. Sutton (12.5.49)

SUB-COMMITTEE ON SWITCHES FOR APPLIANCES (ELE/4/18)
*S. L. M. Barlow (7.2.57)

TECHNICAL COMMITTEE ON ELECTRICAL GLOSSARIES AND GRAPHICAL SYMBOLS (ELE/9)
Prof. M. G. Say, M.SC., PH.D., F.R.S.E. (5.11.59)
The Secretary of The Institution (or his deputy)

SUB-COMMITTEE ON ELECTRICAL NOMENCLATURE AND SYMBOLS—TYPES OF ENCLOSURE (ELE/9/8)
S. J. Emerson (20.5.54)

PANEL ON INTERNATIONAL VOCABULARY OF THE I.E.C. GROUP 25—DISTRIBUTION OF ENERGY (ELE/9/10/25)
T. G. N. Haldane (26.4.56)
(Deputy, R. S. Orchard, M.A.)

COMMITTEE ON ELECTRICAL SWITCH AND CONTROL GEAR (ELE/10)
*J. A. Broughall, B.SC.(ENG.) (7.3.57)

SUB-COMMITTEE ON SWITCHGEAR FOR DOMESTIC AND INDUSTRIAL DUTY (ELE/10/2)
*Appointment pending*

SUB-COMMITTEE ON SWITCHBOARDS (ELE/10/10)
*T. M. H. Stubbs (7.3.57)

SUB-COMMITTEE ON AUTOMATIC CHANGE-OVER CONTACTORS (ELE/10/16)
*E. J. Sutton (15.6.50)

SUB-COMMITTEE ON EARTH LEAKAGE CIRCUIT-BREAKERS (ELE/10/18)
*H. W. Grimmitt, C.B.E. (13.5.48)
*Further appointment pending*

SUB-COMMITTEE ON MINIATURE CIRCUIT-BREAKERS (ELE/10/23)
J. S. McCulloch (6.2.58); Deputy, F. E. Heppenstall

TECHNICAL COMMITTEE ON ELECTRICAL INSTRUMENTS (ELE/13)
R. B. Armstrong, B.SC. (5.4.51); G. F. Tagg, B.SC.(ENG.), PH.D. (6.3.58)

TECHNICAL COMMITTEE ON ELECTRICITY METERS (ELE/14)
H. S. Petch, B.SC.(ENG.) (3.12.59); L. B. S. Golds (12.1.50
G. F. Shotter (28.2.29)

SUB-COMMITTEE ON COMPOSITE BOARDS FOR SWITCHGEAR ETC. (ELE/16/13)
*Appointment pending*

TECHNICAL COMMITTEE ON OVERHEAD LINES (ELE/17)
P. J. Ryle, B.SC.(ENG.) (19.5.55); H. W. Grimmitt, C.B.E. (26.10.55)

SUB-COMMITTEE ON INSULATOR AND CONDUCTOR FITTINGS (ELE/17/7)
W. J. Nicholls, B.SC. (6.1.55)

SUB-COMMITTEE ON PLASTIC-COVERED CONDUCTORS (ELE/17/10)
C. Hughes, B.SC.(ENG.) (8.1.59)

TECHNICAL COMMITTEE ON RAILWAY SIGNALLING APPARATUS (ELE/22)
E. G. Brentnall, M.ENG. (19.6.52)

TECHNICAL COMMITTEE ON TRAMWAY POLES (ELE/24)
T. S. Pick, B.SC.(ENG.) (3.2.49)

TECHNICAL COMMITTEE ON RAILWAY SIGNALLING NOMENCLATURE AND SYMBOLS (ELE/25)
No representative; papers to the Secretary of our Institution

TECHNICAL COMMITTEE ON ELECTRIC FANS (ELE/28)
A. S. Carr, B.SC. (5.11.53)

TECHNICAL COMMITTEE ON RADIO INTERFERENCE SUPPRESSION (ELE/32)
G. O. Watson (22.6.44) (Representing the Ship Electrical Equipment Committee)

PANEL ON ABATEMENT OF INTERFERENCE AT HIGHER FREQUENCIES (ELE/32/–/1)
A. J. Biggs, PH.D., B.SC. (6.12.56)

SUB-COMMITTEE ON RADIO INTERFERENCE FROM IGNITION SYSTEMS ELE/32/2)
W. J. Bray, M.SC. (11.9.58)

SUB-COMMITTEE ON RADIO INTERFERENCE FROM TROLLEYBUSES AND TRAMWAYS (ELE/32/3)
*Appointment pending*

SUB-COMMITTEE ON RECEIVING EQUIPMENT (ELE/32/5)
A. J. Biggs, PH.D., B.SC. (6.12.56)
The Secretary of The Institution (or his deputy)

SUB-COMMITTEE ON MARINE INSTALLATIONS (ELE/32/6)
Sir Archibald J. Gill, B.SC.(ENG.) (6.11.47)
A. G. Stonebanks (5.3.59); G. O. Watson (8.8.39)

SUB-COMMITTEE ON RADIO INTERFERENCE FROM POWER LINES AND ASSOCIATED PLANT (ELE/32/14)
J. S. Forrest, D.SC., M.A. (6.11.58)

TECHNICAL COMMITTEE ON TERMINAL MARKINGS (ELE/41)
*E. J. Sutton (3.11.49)

TECHNICAL COMMITTEE ON EARTHING CLAMPS (ELE/45)
*H. W. Grimmitt, C.B.E. (12.1.50)

TECHNICAL COMMITTEE ON CAPACITORS (ELE/46)
C. G. Garton (3.3.60)
R. C. G. Williams, PH.D., B.SC.(ENG.) (21.4.49)

SUB-COMMITTEE ON LOW-VOLTAGE TRANSFORMERS (ELE/51/1)
A. J. L. Whittenham (16.9.54)

SUB-COMMITTEE ON MARINE TRANSFORMERS (ELE/51/5)
G. J. Tuke, B.SC. (11.9.58)
G. O. Watson (31.3.60)

TECHNICAL COMMITTEE ON CONSUMER SUPPLY CONTROL UNITS (ELE/57
H. C. Spence (31.3.55)

TECHNICAL COMMITTEE ON INSTRUMENT TRANSFORMERS (ELE/59)
G. F. Shotter (22.2.34)

TECHNICAL COMMITTEE ON POWER RATING OF H.F. HEATING EQUIPMENT (ELE/66)
L. Carter Ludbrook, B.ENG. (13.5.48)

TECHNICAL COMMITTEE ON INSULATORS FOR POWER SYSTEMS (ELE/70)
P. K. Davis (31.3.55)

SUB-COMMITTEE ON LINE INSULATION (ELE/70/1)
P. K. Davis (11.5.39); H. Willott Taylor (11.5.39)

COMMITTEE ON FUSES FOR DISTRIBUTION AND SIMILAR PURPOSES (ELE/78)
F. H. Mann (8.11.56)

SUB-COMMITTEE ON MEDIUM-VOLTAGE AND LOW-VOLTAGE FUSES (ELE/78/1)
F. H. Mann (8.11.56); G. O. Watson (8.11.56)

COMMITTEE ON CO-ORDINATION OF TECHNICAL REQUIREMENTS FOR DOMESTIC AND SIMILAR EQUIPMENT (ELE/79)
*F. H. Mann (7.2.57)

PANEL ON REVISION OF MEMORANDUM ON DOUBLE INSULATION (ELE/79/–/1)
Forbes Jackson (15.9.60)

COMMITTEE ON CONDUITS AND CONDUIT FITTINGS FOR ELECTRICAL PURPOSES (ELE/80)
E. E. Hutchings, B.SC.(ENG.) (25.4.57)

COMMITTEE ON NON-METALLIC CONDUIT AND FITTINGS (ELE/80/2)
T. A. Frazer, M.A. (14.5.59)

COMMITTEE ON ELECTRICAL POWER METERING (ELE/81)
F. Byrne (7.11.57)

TECHNICAL COMMITTEE ON DOMESTIC AND SIMILAR ELECTRICAL EQUIPMENT AND APPLIANCES (ELE/82)
S. L. M. Barlow (15.5.58); H. W. Grimmitt, C.B.E. (15.5.58)
F. H. Mann (15.5.58)

SUB-COMMITTEE ON IMMERSION HEATERS AND THERMOSTATS (ELE/82/4)
E. Jacobi (5.3.53)

SUB-COMMITTEE ON PORTABLE TOOLS (ELE/82/12)
F. H. Mann (6.3.52)

SUB-COMMITTEE ON ELECTRIC SHAVER SUPPLY UNITS (ELE/82/19)
H. W. Swann, O.B.E. (13.9.56)

SUB-COMMITTEE ON ELECTRIC CLOCKS (ELE/82/22),
*Appointment pending*

SUB-COMMITTEE ON ELECTRICALLY HEATED CARPET UNDERLAYS (ELE/82/23)
C. E. Mills (7.1.60)

TECHNICAL COMMITTEE ON ELECTRICAL APPARATUS FOR EXPLOSIVE GAS ATMOSPHERES (ELE/83)
F. H. Mann (14.5.59)

SUB-COMMITTEE ON INTRINSIC SAFETY (ELE/83/2)
C. D. Wilkinson (5.2.53)

TECHNICAL COMMITTEE ON ELECTRICAL EQUIPMENT OF MACHINE TOOLS (ELE/84)
E. J. Sutton (1.4.54)

TECHNICAL COMMITTEE ON ELECTRICAL PROTECTIVE SYSTEMS (ELE/85)
G. W. B. Mitchell, B.A. (9.7.59)

* Appointed for liaison with the Wiring Regulations Committee

TECHNICAL COMMITTEE ON FUNDAMENTAL TERMS IN ELECTRICAL ENGINEERING (ELE/TLE/1)
Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D. (5.11.59)
The Secretary of The Institution (or his deputy)

TECHNICAL COMMITTEE ON GRAPHICAL SYMBOLS FOR ELECTRICAL ENGINEERING AND TELECOMMUNICATIONS (ELE/TLE/2)
A. H. M. Arnold, PH.D., D.ENG. (15.5.58)

COMMITTEE ON AIRCRAFT ELECTRICAL UTILIZATION EQUIPMENT (ACE/5)
A. K. Clyde (25.4.57)

COMMITTEE ON AIRCRAFT LAMPS AND LAMPHOLDERS (ACE/5/2)
A. K. Clyde (25.4.57)

COMMITTEE ON AIRCRAFT ELECTRICAL CABLES AND ACCESSORIES (ACE/6)
D. B. McKenzie, B.SC. (25.4.57)

COMMITTEE ON AIRCRAFT INSTRUMENT EQUIPMENT (ACE/30)
A. K. Clyde (25.4.57)

COMMITTEE ON AIRCRAFT ELECTRICAL AND INSTRUMENT REQUIREMENTS (ACE/41)
C. S. Hudson, PH.D., B.SC. (25.4.57)

COMMITTEE ON ROTATING ELECTRICAL MACHINES FOR AIRCRAFT (ACE/42)
V. A. Higgs, B.SC.(25.4.57)

COMMITTEE ON AIRCRAFT SWITCHGEAR (ACE/43)
V. A. Higgs, B.SC. (25.4.57)

ACOUSTICS STANDARDS COMMITTEE (ACM/–)
A. J. King, D.SC., M.SC.TECH. (3.2.49); T. Somerville, B.SC. (20.5.54)

TECHNICAL COMMITTEE ON ACOUSTICAL TERMINOLOGY (ACM/1)
F. E. Williams, M.SC.(ENG.) (8.1.59)
Deputy, E. W. Ayers, B.SC.(ENG.) (5.11.53)

TECHNICAL COMMITTEE ON ARCHITECTURAL ACOUSTICS (ACM/2)
T. Somerville, B.SC. (21.4.49)

TECHNICAL COMMITTEE ON NOISE MEASUREMENT (ACM/3)
J. S. Forrest, D.SC., M.A. (18.9.47)

TECHNICAL COMMITTEE ON AUDIOMETERS (ACM/4)
J. S. Forrest, D.SC., M.A. (18.9.47)

TECHNICAL COMMITTEE ON ELECTRO-ACOUSTIC TRANSDUCERS (ACM/8)
D. E. L. Shorter (2.4.59)

TECHNICAL COMMITTEE ON MEDICAL ULTRASONIC EQUIPMENT (ACM/9)
C. N. Smyth, M.A., B.SC.(ENG.), B.M., B.CHIR. (4.12.58)

TECHNICAL COMMITTEE ON ELECTRICAL FENCES (AGE/1)
H. W. Grimmitt, C.B.E. (16.9.43)

TECHNICAL COMMITTEE ON UNDER-FLOOR DUCT SYSTEMS (B/43)
*E. J. Sutton (12.5.49)
*Further appointment pending*

TECHNICAL COMMITTEE ON METER SPACE (B/65)
H. C. Spence (31.3.55)

SUB-COMMITTEE ON ELECTRICAL METER SPACE (B/65/1)
H. C. Spence (31.3.55)

TECHNICAL COMMITTEE FOR BOILER WATER TESTS (C/37)
W. Wilde, B.SC.(ENG.) (4.3.43)

SUB-COMMITTEE ON CONCRETE TRANSMISSION POLES (CEB/6/5)
N. G. Simpson (26.6.58)

SUB-COMMITTEE ON ELECTROPLATED COATING OF SILVER FOR INDUSTRIAL PURPOSES (CHE/18/9)
D. O. Walter (1.4.54)

TECHNICAL COMMITTEE ON VITREOUS ENAMELS (CHE/22)
E. Jacobi (14.9.44)

SUB-COMMITTEE ON STAGE ELECTRICAL EQUIPMENT (CME/4/7)
*C. E. Mills (6.12.51)

COLLIERY REQUISITES INDUSTRY STANDARDS COMMITTEE (CRE/–)
P. N. Wyke, B.SC. (10.1.52)

TECHNICAL COMMITTEE ON INPUT AND OUTPUT STANDARDS FOR DATA PROCESSING EQUIPMENT (E/149)
W. S. Elliott, M.A. (7.1.60)

TECHNICAL COMMITTEE FOR REVISION OF STANDARD SPECIFICATIONS RELATING TO HOT-WATER TANKS AND CYLINDERS (HIB/7)
E. Jacobi (6.11.52)

INSTRUMENTS INDUSTRY STANDARDS COMMITTEE (INE/–)
Lt.-Col. W. L. Beck, T.D. (15.1.48)
The Chairman of the Measurement and Control Section (*ex officio*)

SUB-COMMITTEE ON GLOSSARY OF TERMS USED IN AUTOMATIC CONTROL SYSTEMS (INE/1/1)
Prof. K. A. Hayes, B.SC.(ENG.) (6.11.47)

PANEL ON AUTOMATIC REGULATORS (INE/1/1/4)
Prof. K. A. Hayes, B.SC.(ENG.) (9.4.53)

PANEL ON GRAPHICAL SYMBOLS FOR THE COMPONENTS OF SERVO-MECHANISMS (INE/1/2/2)
Prof. K. A. Hayes, B.SC.(ENG.) (24.6.54)

TECHNICAL COMMITTEE ON TEMPERATURE MEASUREMENT (INE/4)
H. A. Thomas, D.SC. (30.3.50)

SUB-COMMITTEE ON REFRIGERATION THERMOMETERS ON SHIPS (INE/4/5)
W. Bamford, B.SC. (23.6.55)

TECHNICAL COMMITTEE ON PRESSURE GAUGES (INE/6)
G. A. V. Sowter, PH.D., B.SC.(ENG.) (19.6.52)

TECHNICAL COMMITTEE ON REVOLUTION INDICATORS AND RECORDERS (INE/8)
P. Smith, B.SC. (19.5.60)

SUB-COMMITTEE ON MECHANICAL AND MAGNETIC REVOLUTION INDICATORS AND RECORDERS (INE/8/1)
P. Smith, B.SC. (19.5.60)

SUB-COMMITTEE ON ELECTRICAL ASPECTS OF REVOLUTION INDICATORS AND RECORDERS (INE/8/2)
P. Smith, B.SC. (19.5.60)

TECHNICAL COMMITTEE ON JEWELS AND PIVOTS FOR INSTRUMENTS (INE/11)
G. F. Shotter (19.1.39)
*Further appointment pending*

ILLUMINATION INDUSTRY STANDARDS COMMITTEE (LGE/–)
C. W. M. Phillips (2.12.48); H. R. Ruff, B.SC.(ENG.) (1.4.48)
W. R. Stevens, B.SC. (19.5.55)
J. W. T. Walsh, O.B.E., D.SC., M.A. (8.11.51); G. T. Winch (24.6.54)
The Secretary of The Institution (or his deputy)

TECHNICAL COMMITTEE ON PORTABLE PHOTOMETERS (LGE/1)
G. F. Freeman, M.SC.(ENG.) (15.5.52)
*Further appointment pending*

TECHNICAL COMMITTEE ON ELECTRIC LAMPS (LGE/6)
*N. Sizer, O.B.E., M.C.(23.6.49); G. T. Winch (4.2.54)

SUB-COMMITTEE ON DISCHARGE LAMPS (LGE/6/6)
*N. Sizer, O.B.E., M.C. (23.6.49); G. T. Winch (4.2.54)

SUB-COMMITTEE ON AUXILIARIES (LGE/6/7)
N. Sizer, O.B.E., M.C. (23.6.49)

TECHNICAL COMMITTEE ON PHOTOMETRIC INTEGRATORS (LGE/7)
G. F. Freeman, M.SC.(ENG.) (15.5.52)
*Further appointment pending*

TECHNICAL COMMITTEE ON ELECTRIC SIGNS (LGE/11)
Capt. C. Higgins, O.B.E., B.SC.(ENG.) (4.3.48)
W. R. Stevens, B.SC. (4.11.48); *A. J. L. Whittenham (4.12.47)

TECHNICAL COMMITTEE ON PIPE FLANGES (MEE/11)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON STEAM FLANGES (MEE/11/1)
F. Shakeshaft, O.B.E. (16.9.48)

TECHNICAL COMMITTEE ON ENGINE TESTING FITTINGS (MEE/13)
F. Shakeshaft, O.B.E. (16.9.48)

TECHNICAL COMMITTEE ON PUMP TESTS (MEE/29)
H. R. Ogle (6.1.55)

TECHNICAL COMMITTEE ON LAND BOILERS (MEE/34)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON WATER-TUBE BOILERS (MEE/34/2)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON FITTINGS FOR LAND BOILERS (MEE/34/6)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON ACCESSORIES FOR LAND BOILERS (MEE/34/7)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON BOILER AND SUPERHEATER TUBES (MEE/34/9)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON ELECTRODE BOILERS (MEE/34/12)
H. E. Baker, B.A. (6.11.49)

TECHNICAL COMMITTEE ON COMPRESSORS, EXHAUSTERS AND FANS (MEE/39)
Prof. R. O. Kapp, B.SC. (25.6.53)

SUB-COMMITTEE ON FANS FOR GENERAL PURPOSES (MEE/39/4)
Prof. R. O. Kapp, B.SC. (25.6.53)

SUB-COMMITTEE ON MINE FANS (MEE/39/5)
P. N. Wyke, B.SC. (25.6.53)

TECHNICAL COMMITTEE ON METHODS OF TEST FOR DUST EXTRACTION PLANT (MEE/48)
C. L. Blackburn, B.A. (5.9.34)

TECHNICAL COMMITTEE ON LIFTS, HOISTS AND ESCALATORS (MEE/49)
L. J. Gooch (1.3.45)

TECHNICAL COMMITTEE ON GRAPHICAL SYMBOLS FOR GENERAL ENGINEERING (MEE/88)
The Secretary of The Institution (or his deputy)

TECHNICAL COMMITTEE ON B.S. CLASSIFICATION SCHEME OF PLANT, EQUIPMENT AND TOOLS (MEE/100)
*Appointment pending*

TECHNICAL COMMITTEE ON IDENTIFICATION OF PIPELINES, CABLES AND CONDUITS (MEE/104)
E. Jacobi (23.6.48)

TECHNICAL COMMITTEE ON INTERNAL COMBUSTION ENGINES (MEE/123)
G. O. Watson (16.1.47)
*Further appointment pending*

* Appointed for liaison with the Wiring Regulations Committee

TECHNICAL COMMITTEE ON HYDRAULIC TURBINES (MEE/125)
P. L. Blackstone, T.D., M.A. (19.5.55)

TECHNICAL COMMITTEE ON TERMINOLOGY AND SYMBOLS FOR INDUSTRIAL WORK STUDY (MEE/132)
H. O. Weare (4.12.52)

COMMITTEE ON GAS TURBINES (MEE/143)
B. Wood, M.A. (22.9.55)

COMMITTEE ON PUNCHED CARDS ETC. FOR DATA TRANSMISSION (MEE/149)
R. H. Tizard, B.A. (7.2.57)

SUB-COMMITTEE ON MAGNETIC TAPE FOR USE WITH COMPUTERS (MEE/149/4)
G. A. V. Sowter, PH.D., B.SC.(ENG.) (12.9.57)

SUB-COMMITTEE ON LEAD & LEAD ALLOYS FOR CABLE SHEATHING (NFE/22/3)
C. E. Mills (23.6.49)

TECHNICAL SUB-COMMITTEE (OC/1/3)—MARK SUB-COMMITTEE ON RADIO INTERFERENCE
W. J. Bray, M.SC. (11.9.58)

DOCUMENTATION STANDARDS COMMITTEE (OC/20)
B. M. Crowther, M.A., PH.D. (19.6.47)
The Secretary of The Institution (or his deputy)

TECHNICAL COMMITTEE ON PLASTIC MOULDINGS OF THE THERMOSETTING TYPE (PCL/18)
C. E. Mills (26.6.54)

TECHNICAL COMMITTEE ON SAFETY BELTS (PSM/5)
*Appointment pending*

TECHNICAL COMMITTEE ON SAFETY COLOUR CODE (PSM/12)
F. H. Mann (14.5.53)

TECHNICAL COMMITTEE ON ANTI-STATIC CONDUCTIVE RUBBER AND PLASTICS (RUC/2)
H. K. Cameron, B.SC., PH.D. (3.11.49)

TECHNICAL COMMITTEE ON RUBBER BALATA AND PLASTICS FLAT BELTING (RUC/16)
*Appointment pending*

TECHNICAL COMMITTEE ON RUBBER FLOORING (RUC/33)
*Appointment pending*

TECHNICAL COMMITTEE ON MANUFACTURERS' TRADE AND TECHNICAL LITERATURE (S/14)
*Appointment pending*

TECHNICAL COMMITTEE ON NOMENCLATURE AND DEFINITIONS FOR SOLID-FUEL BURNING APPLIANCES (SFE/1)
J. I. Bernard, B.SC.TECH. (3.3.49)

TECHNICAL COMMITTEE ON THERMAL INSULATING MATERIAL (SFE/14)
J. I. Bernard, B.SC.TECH. (22.6.44)

TECHNICAL COMMITTEE ON BRITISH STANDARD METHODS FOR THE SAMPLING AND ANALYSIS OF FLUE GASES INCLUDING INDICATING AND/OR RECORDING INSTRUMENTS (SFE/17)
C. L. Blackburn, B.A. (20.9.45)

TECHNICAL COMMITTEE ON METHODS FOR TESTING ATMOSPHERIC POLLUTION (INCLUDING INSTRUMENTS) (SFE/21)
R. W. Griffin, B.SC.(ENG.) (9.5.46)

TECHNICAL COMMITTEE ON AIR HEATER BATTERIES (SFE/23)
F. Shakeshaft, O.B.E. (16.9.48)

TECHNICAL COMMITTEE ON COAL AND COKE (SFE/45)
D. P. Sayers, B.SC. (5.2.59)

TELECOMMUNICATIONS INDUSTRY STANDARDS COMMITTEE (TLE/–)
R. E. Robinson (13.9.51); C. E. Strong, O.B.E., B.A., B.A.I. (13.9.51)
Chairman of the Electronics and Communications Section (*ex officio*)

TECHNICAL COMMITTEE ON TERMINOLOGY AND SYMBOLS FOR TELECOMMUNICATION (TLE/1)
Prof. E. C. Cherry, D.SC. (5.2.53)
The Secretary of The Institution (or his deputy) (5.2.53)

SUB-COMMITTEE ON NOMENCLATURE AND LETTER SYMBOLS FOR TELECOMMUNICATION (TLE/1/1)
L. I. Farren, M.B.E. (10.4.58)
The Secretary of The Institution (or his deputy)

SUB-COMMITTEE ON COMPUTER TERMINOLOGY (TLE/1/3)
W. S. Elliott, M.A. (15.5.58)

TECHNICAL COMMITTEE ON RADIO (INCLUDING TELEVISION) RECEIVERS (TLE/2)
R. C. G. Williams, PH.D., B.SC.(ENG.) (5.2.53)

SUB-COMMITTEE ON PERFORMANCE OF RADIO RECEIVERS (TLE/2/1)
B. G. Pressey, PH.D., M.SC.(ENG.) (15.5.52)

SUB-COMMITTEE ON MAINS SUPPLY APPARATUS FOR RADIO RECEIVERS ETC. (TLE/2/2)
*H. G. Gamble (17.3.47); E. M. Lee, B.SC. (6.3.47)
*A. H. F. Linton (7.2.57)

SUB-COMMITTEE ON RADIO (INCLUDING TELEVISION) AERIALS (TLE/2/3)
E. M. Lee, B.SC. (7/11/57)

TECHNICAL COMMITTEE ON RADIO (INCLUDING TELEVISION) TRANSMITTERS (TLE/3)
V. J. Cooper, B.SC.(ENG.) (5.2.53)

SUB-COMMITTEE ON RADIO (INCLUDING TELEVISION) TRANSMITTER PERFORMANCE (TLE/3/1)
E. Green, M.SC. (1.12.55)

SUB-COMMITTEE ON RADIO (INCLUDING TELEVISION) TRANSMITTER SAFETY REQUIREMENTS (TLE/3/2)
Sir Archibald J. Gill, B.SC.(ENG.) (5.2.53)

TECHNICAL COMMITTEE ON COMPONENTS FOR TELECOMMUNICATION EQUIPMENT (TLE/4)
G. J. McDonald, B.SC.(ENG.) (4.3.54)

SUB-COMMITTEE ON CONNECTORS AND SWITCHES FOR TELECOMMUNICATION EQUIPMENT (TLE/4/12)
E. M. Lee, B.SC. (6.12.56)

PANEL ON CONNECTORS FOR TELECOMMUNICATION EQUIPMENT (TLE/4/12/1)
E. M. Lee, B.SC. (6.12.56)

PANEL ON SWITCHES FOR TELECOMMUNICATION EQUIPMENT (TLE/4/12/2)
E. M. Lee, B.SC. (6.12.56)

TECHNICAL COMMITTEE ON TELECOMMUNICATION MEASURING INSTRUMENTS AND TEST EQUIPMENT (TLE/8)
E. D. Hart, M.A. (26.4.56)

SUB-COMMITTEE ON VIBRATION AND BUMP APPARATUS (TLE/8/2)
K. A. F. Frost, B.SC.(ENG.) (30.3.50)

PANEL ON SHOCK AND VIBRATION AND BUMP TERMINOLOGY (TLE/8/2/1)
*Appointment pending*

TECHNICAL COMMITTEE ON TELECOMMUNICATION MEASURING INSTRUMENTS AND TEST EQUIPMENT—SIGNAL GENERATORS (TLE/8/3)
D. P. E. Brown (3.3.60)

TECHNICAL COMMITTEE ON TELECOMMUNICATION MEASURING INSTRUMENTS AND TEST EQUIPMENT—ELECTRONIC INSTRUMENTS FOR VOLTAGE MEASUREMENT (TLE/8/4)
D. P. E. Brown (3.3.60)

TECHNICAL COMMITTEE ON AIRCRAFT RADIO EQUIPMENT (TLE/9)
K. A. F. Frost, B.SC.(ENG.) (30.3.50)
C. E. Strong, O.B.E., B.A., B.A.I. (8.2.46)

SUB-COMMITTEE ON AIRCRAFT RADIO EQUIPMENT CONNECTORS (TLE/9/1)
*Appointment pending*

UNITS AND SYMBOLS STANDARDS COMMITTEE (USM/–)
Col. J. Reading, M.B.E., B.SC.(ENG.) (6.12.51)
The Secretary of The Institution (or his deputy)

CO-ORDINATION OF DEFINITIONS, UNITS AND TECHNICAL DATA COMMITTEE (USM/1)
Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D. (17.5.56)
Prof. R. O. Kapp, B.SC. (1.1.45)
The Secretary of The Institution (or his deputy)

SUB-COMMITTEE ON GLOSSARY OF TERMS USED IN NUCLEAR SCIENCE (USM/1/8)
Denis Taylor, M.SC., PH.D. (13.9.56)

SUB-COMMITTEE ON ELECTRICAL UNITS AND MAGNITUDES (USM/1/9)
Prof. M. G. Say, M.SC., PH.D., F.R.S.E. (5.11.59)

TECHNICAL COMMITTEE ON ABBREVIATIONS AND LETTER SYMBOLS (USM/2)
Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D. (5.11.59)
Prof. M. G. Say, M.SC., PH.D., F.R.S.E. (3.12.59)
The Secretary of The Institution (or his deputy)

SUB-COMMITTEE ON LETTER SYMBOLS, SIGNS AND ABBREVIATIONS (ELECTRICAL ENGINEERING) (USM/2/6)
Prof. M. G. Say, M.SC., PH.D., F.R.S.E. (3.3.60)
G. E. Williams, B.SC.(ENG.) (17.9.59)

SUB-COMMITTEE ON ELECTRICAL ABBREVIATIONS AND LETTER SYMBOLS (USM/2/9)
Prof. M. G. Say, M.SC., PH.D., F.R.S.E. (3.12.59)

COMMITTEE ON STATISTICAL METHODS (STANDARDIZATION AND SPECIFICATIONS) (USM/3)
P. Schiller, DIPL.-ING. (10.4.58)
The Secretary of The Institution (or his deputy)

WELDING INDUSTRY STANDARDS COMMITTEE (WEE/–)
A. E. Villiers, M.A. (17.9.53)

TECHNICAL COMMITTEE ON DEFINITIONS AND SYMBOLS FOR WELDING (WEE/1)
A. E. Villiers, M.A. (11.9.58)

TECHNICAL COMMITTEE ON ARC WELDING PLANT (WEE/6)
A. E. Villiers, M.A. (18.9.47)

TECHNICAL COMMITTEE ON RESISTANCE WELDING EQUIPMENT (WEE/26)
F. C. Duffield, (7.11.57)

## Brunel College of Technology

GOVERNING BODY
D. P. Sayers, B.SC.(23.5.57)

ADVISORY PANEL IN ELECTRICAL ENGINEERING AND ELECTRONICS
K. M. Jones (4.12.58)

## Buckinghamshire Education Committee

ADVISORY COMMITTEE FOR ENGINEERING (NORTH BUCKS. AREA)
G. E. Middleton, M.A. (22.9.55)

* Appointed for liaison with the Wiring Regulations Committee

**Bury Technical College**
ENGINEERING ADVISORY COMMITTEE
J. Mills (8.11.51)

**Cannock Chase Mining and Technical College**
ENGINEERING ADVISORY COMMITTEE
J. C. Christie, B.SC. (5.3.59)

**Welsh College of Advanced Technology**
GOVERNING BODY
J. Vaughan Harries (4.4.57)

ADVISORY SUB-COMMITTEE FOR THE DEPARTMENT OF APPLIED PHYSICS AND ELECTRICAL ENGINEERING
J. Vaughan Harries (4.2.54)

**Caroline Haslett Trust Committee**
J. W. Leach (17.5.51)

**City and Guilds of London Institute**
ADVISORY COMMITTEE ON ELECTRICAL ENGINEERING PRACTICE
G. F. Freeman, M.SC.(ENG.) (22.9.55)

ADVISORY COMMITTEE FOR ELECTRICAL FITTERS' COURSE
C. C. Hitchen (5.12.57)

ADVISORY COMMITTEE ON ELECTRICAL INSTALLATION WORK
W. F. Parker (22.9.55)

ADVISORY COMMITTEE FOR ELECTRICAL TECHNICIANS' COURSES
Prof. M. W. Humphrey Davies, M.SC. (26.4.56)
K. R. Sturley, PH.D., B.SC. (17.5.56)

ADVISORY COMMITTEE ON METAL FINISHING (INCLUDING ELECTRO-DEPOSITION OF METALS)
Prof. J. W. Cuthbertson, D.SC. (4.4.57)

ADVISORY COMMITTEE ON ILLUMINATING ENGINEERING
G. F. Freeman, M.SC.(ENG.) (16.9.54)

ADVISORY COMMITTEE ON INSTRUMENT MAINTENANCE
F. O. Morrell, B.SC. (13.9.56)

ADVISORY COMMITTEE ON MACHINE SHOP ENGINEERING
C. C. Hitchen (22.9.55)

ADVISORY COMMITTEE FOR MECHANICAL AND ELECTRICAL ENGINEERING INSPECTION
Lt.-Cmdr. R. B. Fairthorne, R.N.(RET.) (1.4.54)

ADVISORY COMMITTEE ON MINING EDUCATION
B. L. Metcalf, B.SC.(ENG.) (9.10.52)

ADVISORY COMMITTEE ON WELDING
A. C. Davies, B.SC. (18.9.47)

ADVISORY COMMITTEE ON TECHNICAL ILLUSTRATION
C. T. Rivington, M.A. (23.6.55)

ADVISORY COMMITTEE FOR RADIO AMATEURS' EXAMINATION
R. C. G. Williams, PH.D., B.SC.(ENG.) (23.6.48)

ADVISORY COMMITTEE ON TELECOMMUNICATIONS ENGINEERING
R. C. G. Williams, PH.D., B.SC.(ENG.) (27.6.57)

ADVISORY COMMITTEE FOR RADIO SERVICE WORK
R. C. G. Williams, PH.D., B.SC.(ENG.) (23.6.48)

ADVISORY COMMITTEE FOR RADIO AND TELEVISION SERVICING
R. C. G. Wiliiams, PH.D., B.SC.(ENG.) (14.5.59)

ADVISORY COMMITTEE ON PLANT ENGINEERING
G. V. Sadler (22.9.55)

EXPLORATORY COMMITTEE FOR TECHNICAL AUTHORSHIP
G. E. Williams, B.SC.(ENG.) (25.4.57)

EXPLORATORY COMMITTEE ON EXAMINATIONS IN ENGINEERING DRAWING
Prof. M. W. Humphrey Davies, M.SC. (23.5.57)

ADVISORY COMMITTEE ON INDUSTRIAL RADIOGRAPHY
A. Nemet, DR.-ING. (6.11.52)

ADVISORY COMMITTEE ON INSTRUMENT MAKING
J. E. Richardson, PH.D., B.ENG. (9.10.52)

ADVISORY COMMITTEE ON STEAM UTILIZATION
R. H. Coates, B.SC.(ENG.) (23.4.53)

ADVISORY COMMITTEE ON TURBINE HOUSE OPERATION
D. P. Sayers, B.SC. (8.11.56)

FELLOWSHIP COMMITTEE
Sir Gordon Radley, K.C.B., C.B.E., PH.D.(ENG.) (15.5.52)

TECHNOLOGY COMMITTEE
Prof. M. W. Humphrey Davies, M.SC. (4.11.48)

**City of Birmingham Education Department**
ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING FOR TECHNICAL COLLEGES IN BIRMINGHAM OTHER THAN THE BIRMINGHAM COLLEGE OF TECHNOLOGY
L. L. Tolley, B.SC.(ENG.) (5.3.59)

ENGINEERING ADVISORY COMMITTEE
H. S. Davidson, T.D. (3.11.55)

**City of Portsmouth College of Technology**
ENGINEERING ADVISORY COMMITTEE
E. A. Logan, M.SC. (7.2.57)

**College of Aeronautics, Cranfield**
GOVERNING BODY
*Appointment pending*

**C.C.I.R.—Study Group No. 14 on 'Vocabulary'**
BRITISH NATIONAL STUDY COMMITTEE
R. L. Smith-Rose, C.B.E., D.SC., PH.D. (11.9.58)

**Commission mixte internationale**
P. J. Ryle, B.SC.(ENG.) (2.2.50)

**Cornish Engines Preservation Society**
Sir Archibald J. Gill, B.SC.(ENG.) (13.9.56)

**Council for the Preservation of Rural England**
J. R. Beard, C.B.E., M.SC. (11.9.58)

**Council for the Preservation of Rural Wales**
GENERAL COMMITTEE
J. Vaughan Harries (2.4.59)

**Croydon Technical College**
GOVERNING BODY
F. J. Lane, O.B.E., M.SC. (19.5.60)

ELECTRICAL ENGINEERING ADVISORY COMMITTEE
F. J. Lane, O.B.E., M.SC. (22.9.55)

**Darlington College of Further Education**
GOVERNING BODY
D. B. Hogg, M.B.E. (5.11.53)

ELECTRICAL ENGINEERING ADVISORY SUB-COMMITTEE
T. A. George (14.5.59)

**Delhi Engineering College Trust**
EXECUTIVE COMMITTEE
Sir Willis Jackson, D.SC., F.R.S. (5.11.59)

**Department of Scientific and Industrial Research**
STANDING CONSULTATIVE CONFERENCE ON BUILDING RESEARCH AND DEVELOPMENT
R. A. Marryat (17.9.59)

**Dow Prize Board**
A. G. Ramsay, C.B.E., B.SC.(ENG.) (8.11.51)

**East Anglian Regional Advisory Council for Further Education**
EASTERN AREA ENGINEERING SUB-COMMITTEE
J. A. Summer (12.1.50)

WESTERN AREA ENGINEERING SUB-COMMITTEE
Capt. N. Hiller, B.SC.(ENG.) (31.3.55 )

**East Berkshire College of Further Education**
ELECTRICAL ENGINEERING ADVISORY COMMITTEE
A. F. Wilkins, O.B.E., M.SC.TECH. (19.6.52

**East Ham Technical College**
ENGINEERING ADVISORY COMMITTEE
C. R. Stoner, B.SC.(ENG.) (7.1.60)

**East Midlands Regional Advisory Council for Further Education**
ADVISORY PANEL FOR THE ENGINEERING INDUSTRY
Maj. H. E. Knight (5.4.56)

**Economic Commission for Europe**
WORKING PARTY ON INTERNATIONAL CONTRACT PRACTICES IN ENGINEERING
K. F. A. Johnston (18.9.52)
J. F. St.G. Shaw, B.SC.(ENG.) (4.3.54)

**Electrical Association for Women**
NATIONAL ADVISORY COUNCIL
C. T. Melling, C.B.E., M.SC.TECH. (10.4.58)

COMMITTEE FOR TRAINING OF WOMEN DEMONSTRATORS
J. R. Beard, C.B.E., M.SC. (4.11.37)

**Engineering Institutions' Examination Part I Committee**
Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D. (6.11.58)
H. L. Haslegrave, M.A., PH.D., M.SC.(ENG.) (5.11.59)
C. T. Melling, C.B.E., M.SC.TECH. (3.11.60)

**Engineering Joint Examination Board**
Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.) (8.11.56)
Prof. J. Greig, M.SC., PH.D. (5.11.59)

**Engineering Standards Co-Ordinating Committee**
ELECTRICAL ADVISORY BOARD
F. Jervis Smith (23.6.49)

**Exeter Central Technical College**
ELECTRICAL ADVISORY PANEL
G. B. Devey (31.3.60); R. H. Upton, M.ENG. (31.3.60)

**Fire Offices' Committee Fire Protection Association**
COMMITTEE ON THE USE OF ELECTRICITY IN INDUSTRY
Forbes Jackson (3.11.55)

**Glasgow Careers Council**
PANEL OF ADVISERS
A. P. MacKim (23.6.48)

**Great Britain–U.S.S.R. Association**
COUNCIL
Sir Josiah Eccles, C.B.E., D.SC. (3.12.59)

**Hackney Technical College**
BOARD OF GOVERNORS
F. T. Chapman, C.B.E., D.SC.(ENG.) (15.9.49)

**Imperial College of Science and Technology**
BOARD OF GOVERNORS
Sir Willis Jackson, D.SC., F.R.S. (11.9.58)

**Industrial Fuel Efficiency Exhibition**
ORGANIZING COMMITTEE
H. V. Pugh (17.9.59)

**Institute of Fuel**
COUNCIL
W. N. C. Clinch (15.5.52)
ADVISORY COMMITTEE FOR FUEL EFFICIENCY AND POWER FOR INDUSTRY EXHIBITION
H. V. Pugh (3.3.60)

**Institution of Civil Engineers**
COMMITTEE ON SOIL CORROSION OF METALS AND CEMENT PRODUCTS
H. W. Grimmitt (20.9.46); H. W. Swann, O.B.E. (20.9.46)

**Institution of Mechanical Engineers/B.S.I. Committee on Code for the Testing of Boilers**
F. W. Lawton (26.4.45); F. Shakeshaft, O.B.E. (26.4.45)

**International Commission on Irrigation and Drainage**
BRITISH NATIONAL COMMITTEE
B. Donkin, B.A. (6.3.58)

**International Conference on Fatigue of Metals**
ORGANIZING COMMITTEE
G. R. Peterson, B.A. (31.3.55)

**International Conference on Large Electric Systems (C.I.G.R.É.)**
BRITISH NATIONAL COMMITTEE
C. O. Boyse, B.SC.(ENG.) (30.3.50)
S. E. Goodall, M.SC.(ENG.), F.Q.M.C. (28.6.51)
H. W. Grimmitt (30.3.50); F. J. Lane, O.B.E., M.SC. (5.1.61)
D. P. Sayers, B.SC. (5.3.59)
E. L. E. Wheatcroft, M.A. (30.3.50)

**International Conference on Large Electric Systems (C.I.G.R.É.)**
IRISH NATIONAL COMMITTEE
A. J. Litton, B.E., B.SC. (3.11.55)

**International Electrotechnical Commission**
BRITISH NATIONAL COMMITTEE
Sir John Hacking (7.2.52); C. E. Strong, O.B.E., B.A., B.A.I. (7.2.52)
G. T. Winch (24.6.54); The Secretary of The Institution

**International Union for Electroheat**
BRITISH NATIONAL COMMITTEE
R. H. Barfield, D.SC. (6.3.58); H. J. Gibson, B.SC. (6.3.58)
O. W. Humphreys, C.B.E., B.SC. (6.3.58); E. May, B.SC. (6.3.58)
Sir Henry Clay, BART., M.A. (10.4.58)

**Ipswich Civic College**
COUNCIL FOR ENGINEERING
H. V. Pugh (5.12.57)

**Joint British Committee for Stress Analysis**
J. S. Forrest, D.SC., M.A. (19.5.60); Deputy, N. Kerruish, M.A. (19.5.60)

**Joint British Committee for Vacuum Science and Technology**
J. Blears, B.SC.(ENG.) (9.7.59)
Prof. M. R. Gavin, M.B.E., M.A., D.SC. (9.7.59)

**Joint Committee on the Applications of Electricity to Aircraft**
D. C. Flack, B.SC.(ENG.), PH.D. (8.1.59)
Group-Capt. A. Foden, B.SC.TECH., R.A.F. (8.1.59)
R. Hilton, M.ENG. (8.1.59); H. F. Innocent (8.1.59)
J. C. Rivett, B.SC.(ENG.) (15.9.60); Prof. G. A. Whitfield (8.1.59)

**Joint Committee for National Certificates and Diplomas in Electrical Engineering (England and Wales)**
Prof. M. W Humphrey Davies, M.SC. (5.11.53)
J. B. Higham, PH.D., B.SC. (3.11.60); E. R. L. Lewis, M.A. (8.11.56)

**Joint Committee for National Certificates and Diplomas in Electrical Engineering (Northern Ireland)**
Prof. T. P. Allen, M.SC. (21.5.48)
J. W. R. Murland, B.SC.(ENG.) (6.11.58)
T. S. Wylie (8.1.59)

**Joint Committee for National Certificates and Diplomas in Electrical Engineering (Scotland)**
Prof. E. G. Cullwick, O.B.E., M.A., D.SC. (3.11.60); W. B. Laing (8.11.56)
Prof. M. G. Say, PH.D., M.SC., F.R.S.E. (7.11.46)
J. Stewart, M.A., B.SC. (3.11.55)

**Joint Co-Ordinating Committee for Lectures for Schools**
E. L. E. Wheatcroft, M.A. (7.12.50)

**Joint E.D.A./B.S.I. Advisory Committee on Electrical Appliances and Accessories**
J. R. Beard, C.B.E., M.SC. (18.9.47); *Forbes Jackson (6.12.56)

**King's College, Durham University**
ELECTRICAL ENGINEERING COMMITTEE
Chairman of the North-Eastern Centre (*ex officio*)

**Kingston Technical College**
BOARD OF GOVERNORS
J. W. T. Walsh, O.B.E., D.SC., M.A. (11.9.58)
ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING
J. W. T. Walsh, O.B.E., D.SC., M.A. (13.9.56)

**Kuala Lumpur Technical College**
ADVISORY COMMITTEE ON ENGINEERING
W. G. Scott, B.SC. (17.9.53); P. J. Tyrell (21.4.55)

**Lanchester College of Technology, Coventry**
GOVERNING BODY
C. F. Freeman, B.SC.(ENG.) (15.9.60)

**L.C.C. Committee**
ROBERT BLAIR FELLOWSHIP
S. E. Goodall, M.SC.(ENG.), F.Q.M.C. (16.9.48)

**Leeds College of Technology**
ELECTRICAL ENGINEERING TRADES ADVISORY SUB-COMMITTEE
H. Hurworth (12.9.57)

**Leicester College of Technology and Commerce**
ENGINEERING TRADES ADVISORY COMMITTEE
L. Rushforth, M.B.E., B.SC. (13.9.56)

**Lloyd's Register of Shipping**
TECHNICAL COMMITTEE
Sir Archibald J. Gill, B.SC.(ENG.) (25.6.59)

**Loughborough College of Technology**
GOVERNING BODY
G. S. C. Lucas, O.B.E., F.C.G.I. (18.9.52)
ADVISORY COMMITTEE ON ELECTRICAL ENGINEERING
G. S. C. Lucas, O.B.E., F.C.G.I. (11.9.58)
ADVISORY COMMITTEE ON INDUSTRIAL ENGINEERING
D. J. Mynall, B.SC.(ENG.) (3.3.60)

**Malaya—Central Advisory Committee on Technical and Vocational Education and Training**
J. Sharples, B.SC.(ENG.) (17.9.53)

**Manchester College of Science and Technology**
COURT OF GOVERNORS
Sir Willis Jackson, D.SC., F.R.S. (22.9.55)

**Metalliferous Mining (Cornwall) School**
GOVERNING BODY
F. Bowles (6.12.56)

**Ministry of Labour and National Service**
ENGINEERING ADVISORY PANEL
B. L. Metcalf, B.SC.(ENG.) (9.7.59)
C. E. Strong, O.B.E., B.A., B.A.I. (5.11.59)
The Secretary of The Institution (9.7.59)

**Ministry of Labour and National Service (Leeds)**
PANEL OF ADVISORS
A. J. Coveney (8.1.59)

**Monmouthshire Education Committee**
TECHNICAL EDUCATION SUB-COMMITTEE
W. Lloyd Williams (11.9.58)

**National Advisory Committee on Mining Education**
B. L. Metcalf, B.SC.(ENG.) (25.5.50)

**National Advisory Council on Education for Industry and Commerce**
SUB-COMMITTEE FOR NATIONAL CRAFTSMEN'S CERTIFICATES IN ENGINEERING
B. L. Metcalf, B.SC.(ENG.) (15.9.49)

**National Approvals and Marking Scheme for Domestic Electrical Equipment**
PROVISIONAL COMMITTEE
Forbes Jackson (6.2.58)

**National Committee on Space Research**
J. S. McPetrie, PH.D., D.SC. (5.3.59)

* Appointed for liaison with the Wiring Regulations Committee

**National Council for Technological Awards**
BOARD OF STUDIES IN ENGINEERING
S. E. Goodall, M.SC.(ENG.), F.Q.M.C. (22.9.55); G. S. C. Lucas, O.B.E., F.C.G.I. (22.9.55)

**National Illumination Committee of Great Britain**
C. W. M. Phillips (2.12.48); H. R. Ruff, B.SC.(ENG.) (1.4.48)
W. R. Stevens (22.9.55); J. W. T. Walsh, O.B.E., D.SC., M.A. (8.11.51)
G. T. Winch (24.6.54); The Secretary of The Institution
COMMITTEE OF ADMINISTRATION
G. T. Winch (1.7.60)

**National Inspection Council for Electrical Installation Contracting**
NATIONAL INSPECTION BOARD
S. E. Goodall, M.SC.(ENG.), F.Q.M.C. (8.11.56)—alternate R. A. Marryat, B.SC.(ENG.) (10.1.57)
Forbes Jackson (21.4.55)—alternate S. J. Emerson (13.9.56)

**National Joint Advisory Council for the Electricity Supply Industry**
EDUCATION AND TRAINING COMMITTEE [NO. 1 SUB-COMMITTEE (ENGINEERING)]
F. T. Chapman, C.B.E., D.SC.(ENG.) (15.9.49)

**National Society for Clean Air**
EXECUTIVE COUNCIL
A. R. Cooper, M.ENG. (23.6.60)
NORTH-WESTERN DIVISIONAL COUNCIL
H. G. Bell, M.SC.TECH. (12.9.57)
SCOTTISH DIVISION
R. J. Rennie, B.SC. (7.2.52)
YORKSHIRE DIVISIONAL COUNCIL
A. J. Coveney (26.6.58); Deputy, W. J. A. Painter (26.6.58)

**Newcastle upon Tyne College of Further Education**
GOVERNING BODY
J. Christie (15.5.58)

**Newport and Monmouthshire College of Technology**
ENGINEERING ADVISORY COMMITTEE
W. E. Richardson (3.11.60)

**North Riding of Yorkshire Education Committee**
ESTON ENGINEERING ADVISORY COMMITTEE
E. H. Jordan (12.5.49)

**Northern Advisory Council for Further Education**
ADVISORY COMMITTEE ON ENGINEERING
A. T. Crawford, B.SC. (12.5.49)
FUEL TECHNOLOGY COMMITTEE
J. B. Jackson (5.11.53)
SUB-COMMITTEE ON ADVANCED COURSES IN ELECTRICAL ENGINEERING
A. T. Crawford, B.SC. (3.12.53); E. C. Rippon (3.12.53)
T. W. Wilcox (3.12.53)

**Northern Ireland Ministry of Education**
ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING
J. W. R. Murland, B.SC.(ENG.) (26.6.58)

**Norwood Technical College**
TELECOMMUNICATIONS CONSULTATIVE COMMITTEE
R. C. G. Williams, PH.D., B.SC.(ENG.) (27.6.57)

**Nottingham (City) Education Committee**
ELECTRICAL ENGINEERING ADVISORY COMMITTEE
*Appointment pending*

**Nottingham, Nottinghamshire and Derby Education Authorities' Advisory Committee**
*Appointment pending*

**Nottingham Technical College**
ELECTRICAL ENGINEERING ADVISORY COMMITTEE
R. H. Price (7.1.60)

**Nottingham University**
COURT OF GOVERNORS
J. H. Mitchell, PH.D., B.SC. (5.2.59)
ENGINEERING ADVISORY COMMITTEE
G. S. Bosworth, M.A. (8.10.53)

**Paddington Technical College**
BOARD OF GOVERNORS
D. W. Hopkin (3.12.53)

**Parliamentary and Scientific Committee**
GENERAL COMMITTEE
Sir Harold Bishop, C.B.E., B.SC.(ENG.) (31.3.55)
The Secretary of The Institution (23.5.57)

**Paul Instrument Fund Committee**
P. Dunsheath, C.B.E., M.A., D.SC.(ENG.), LL.D. (5.11.59)

**Poplar Technical College**
GOVERNING BODY
W. H. L. Lythgoe (15.9.49)

**Reading Technical College**
ENGINEERING ADVISORY COMMITTEE
A. G. Beverstock, B.SC. (24.4.52)

**Regional Advisory Council for Technical and Other Forms of Further Education for the North-West**
POST ADVANCED EDUCATION SUB-COMMITTEE
H. G. Bell, M.SC.TECH. (8.11.51); B. G. Churcher, M.SC. (19.5.55)
F. W. Taylor, M.SC.TECH. (16.1.47)

**Regional Advisory Council for Higher Technological Education (London and Home Counties)**
ELECTRICAL ENGINEERING ADVISORY COMMITTEE
Prof. M. W. Humphrey Davies, M.SC. (11.9.58)
N. C. Stamford, M.SC. (3.2.55)

**Royal Air Force Education Advisory Committee**
*Appointment pending*

**Royal Aircraft Establishment, Farnborough**
ADVISORY BOARD
Prof. J. Greig, M.SC., PH.D. (22.9.55)

**Royal Society**
BRITISH NATIONAL COMMITTEE FOR PHYSICS
Sir Willis Jackson, D.SC., F.R.S. (15.9.60)
BRITISH NATIONAL COMMITTEE FOR SCIENTIFIC RADIO
J. A. Saxton, D.SC., PH.D. (1.12.60)
R. L. Smith-Rose, C.B.E., D.SC., PH.D. (7.11.57)
GENERAL BOARD OF THE NATIONAL PHYSICAL LABORATORY
Sir Harold Bishop, C.B.E., B.SC.(ENG.) (7.1.60)
Sir Archibald J. Gill, B.SC.(ENG.) (10.1.57)

**Royal Technical College, Salford**
ENGINEERING ADVISORY COMMITTEE
F. Warburton Taylor, M.SC.TECH. (17.5.56)

**Rugby College of Engineering Technology**
GOVERNING BODY
L. Drucquer (23.6.60)

**Rutherford College of Technology**
GOVERNING BODY
H. H. Mullens, B.SC. (7.3.57)
ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING
J. Christie (7.2.52); J. F. Skipsey, B.SC. (14.5.59)

**School of Electronics (Ministry of Supply)**
GOVERNING BODY
F. T. Chapman, C.B.E., D.SC.(ENG.) (2.3.50)

**Slough College of Further Education**
ADVISORY COMMITTEE FOR ENGINEERING
A. F. Wilkins, O.B.E., M.SC.TECH. (19.6.52)

**South-East London Technical College**
BOARD OF GOVERNORS
D. P. Sayers, B.SC. (11.9.58)
ELECTRICAL ENGINEERING CONSULTATIVE COMMITTEE
D. P. Sayers, B.SC. (25.6.59)

**South Shields Marine and Technical College**
GOVERNING BODY
J. Christie (25.6.59)

**Southend on Sea Municipal College**
ENGINEERING ADVISORY COMMITTEE
H. T. Prior, B.SC.(ENG.) (19.6.52)

**Southern Regional Council for Further Education**
ADVISORY COMMITTEE ON ELECTRICAL ENGINEERING
R. H. Coates, B.SC.(ENG.) (7.10.48)
REGIONAL ADVISORY COMMITTEE FOR FUEL TECHNOLOGY
E. McCabe (22.9.55)

**South-Western Regional Council for Further Education**
NORTHERN AREA ENGINEERING ADVISORY SUB-COMMITTEE
A. G. Milne (17.9.59)
SOUTHERN AREA ENGINEERING ADVISORY SUB-COMMITTEE
S. G. Monk, M.SC.(ENG.), B.SC. (8.1.53)

**Stafford College of Technology**
GOVERNING BODY
J. E. Boul, A.C.G.I. (2.4.59)

**Stockport College for Further Education**
ENGINEERING ADVISORY COMMITTEE
H. G. Brown (5.3.59)

**Swansea Technical College**
ADVISORY COMMITTEE FOR ENGINEERING
T. Gill, B.SC. (6.11.58)

**Taunton Technical College**
ADVISORY COMMITTEE FOR ENGINEERING AND SCIENCE
D. George (6.3.58)

**Unesco**
UNITED KINGDOM COMMITTEE ON NATURAL SCIENCES
The Secretary of The Institution (*ex officio*) (2.2.50)

**Union of Lancashire and Cheshire Institutes**
ENGINEERING ADVISORY COMMITTEE
Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D. (19.5.55)
PANEL FOR ENGINEERING
Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D. (19.5.55)

**Wallasey Technical College**
GOVERNING BODY
J. Collins (22.9.55)

**Wandsworth Technical College**
BOARD OF GOVERNORS
D. W. Hopkin (5.4.56)

**Welsh Academic Board of Technology**
ENGINEERING SUB-COMMITTEE
*Appointment pending*

**Welsh Joint Education Committee**
TECHNICAL EDUCATION COMMITTEE
J. Vaughan Harries (5.10.50)

**West Ham College of Technology**
ELECTRICAL ENGINEERING ADVISORY COMMITTEE
C. E. Strong, O.B.E., B.A., B.A.I. (5.11.59)

**West Midlands Advisory Council for Further Education**
ELECTRICAL ENGINEERING ADVISORY COMMITTEE
C. F. Partridge, B.SC.(ENG.) (1.12.60)

**West Midlands Advisory Council for Technical, Commercial and Art Education**
ELECTRICAL ENGINEERING ADVISORY COMMITTEE
D. A. Bell, M.A., B.SC. (2.2.56)

**Widnes College of Further Education**
ENGINEERING ADVISORY COMMITTEE
T. E. Houghton, M.ENG. (13.9.56)

**Wolverhampton and Staffordshire College of Technology**
ELECTRICAL AND MECHANICAL ADVISORY COMMITTEE
W. J. Gibbs, D.SC. (5.11.53)

**Women's Engineering Society**
COUNCIL
Sir Willis Jackson, D.SC., F.R.S. (9.7.59)

**Worcester Education Committee**
ENGINEERING ADVISORY COMMITTEE
H. J. Gibson, B.SC. (3.11.55)

**World Power Conference**
BRITISH NATIONAL COMMITTEE
J. R. Beard, C.B.E., M.SC. (17.9.53)

**Yorkshire Council for Further Education**
ELECTRICAL ENGINEERING COMMITTEE
G. Caton (14.5.59)
ELECTRICAL AND MECHANICAL ENGINEERING ADVISORY COMMITTEE
JOINT SUB-COMMITTEE
G. H. Fletcher (5.4.51)
COAL MINING ADVISORY COMMITTEE
J. Mann (1.2.51)
LEEDS–HULL ACADEMIC BOARD
J. D. Nicholson, B.SC. (19.5.55)

---

# Codes of Practice Council

## Council for Codes of Practice (CP/-)

*Institution nominees:*
C. T. Melling, C.B.E., M.SC.TECH. (15.9.60)
S. E. Goodall, M.SC.(ENG.), F.Q.M.C. (17.4.57)
*ELCP/- nominees:*
The Chairman of ELCP/- (*ex officio*)
J. I. Bernard, B.SC.TECH.
A. H. Young

## Codes of Practice Committee for Electrical Engineering (ELCP/-)

| | |
|---|---|
| *Chairman:* Forbes Jackson | F. H. Mann |
| F. H. Mann | R. A. Marryat, B.SC.(FNG.) |
| C. A. Cameron Brown, B.SC. | E. L. E. Pawley, O.B.E., M.SC.(ENG.) |
| H. M. Lacey, B.SC.(ENG.) | A. H. Young |
| *and* | *Nominated by* |
| J. Brierley, B.A. | Air Ministry |
| W. McDermott, B.SC.TECH. | Associated Offices Technical Committee |
| Sir Henry Clay, BART., M.A. | Association of Consulting Engineers |
| J. Flood | Association of Supervising Electrical Engineers |
| E. E. Hutchings, B.SC.(ENG.) | British Electrical and Allied Industries Research Association |
| T. M. H. Stubbs | British Electrical and Allied Manufacturers' Association |
| T. S. Pick, B.SC.(ENG.) | British Transport Commission |
| *S. E. Goodall, M.SC.(ENG.), F.Q.M.C. | Cable Makers Association |
| M. D. Stonehouse, M.B.E. | Central Electricity Generating Board |
| R. H. Jones, M.SC. | Crown Agents for Oversea Governments and Administrations |
| J. Comrie | D.S.I.R. Building Research Station |
| W. J. Jones, M.SC.(ENG.) | Electric Lamp Industry Council |
| **Miss Mary George, M.B.E. | Electrical Association for Women |
| A. V. Milton | Electrical Contractors' Association |
| A. C. C. Smith | Electrical Contractors' Association of Scotland |
| E. P. Fairbairn, B.SC. | Electronic Engineering Association |
| W. J. Outram | Engineering Equipment Users' Association |
| †C. E. Mills | Fire Offices' Committee |
| W. R. Stevens, B.SC. | Illuminating Engineering Society |
| R. H. Coates, B.SC.(ENG.) | Institution of Mechanical Engineers |
| S. J. Emerson, M.ENG. | Ministry of Labour |
| A. H. F. Linton | Ministry of Power |

* Deputy, J. R. Cox
† Deputy, W. R. Whittington
** Deputy, Mrs. M. E. Pickford

| | |
|---|---|
| ‡P. McKearney, O.B.E. | Ministry of Works |
| P. N. Wyke, B.SC. | National Coal Board |
| E. J. Sutton | National Inspection Council for Electrical Installation Contracting |
| *Appointment pending* | North of Scotland Hydro-Electric Board |
| E. W. Anderson, B.SC.(ENG.) | Post Office |
| E. M. Lee, B.SC. | Radio and Electronic Component Manufacturers' Federation |
| Thomas Mitchell, M.B.E., B.SC., A.R.I.B.A. | Royal Institute of British Architects |
| G. S. Wilton, B.SC. | South of Scotland Electricity Board |
| H. Faulkner, C.M.G., B.SC.(ENG.) | Telecommunication Engineering and Manufacturing Association |

## Code Drafting Committee on Farm and Horticultural Electrical Installations (ELCP/1)

*Chairman:* C. A. Cameron Brown, B.SC.
*Institution nominees:* J. I. Bernard, B.SC.TECH.; H. W. Grimmitt, C.B.E.; F. E. Rowland

## Code Drafting Committee on Electrical Installations (ELCP/2)

*Chairman:* R. A. Marryat, B.SC.(ENG.)
*Institution nominees:*
J. Flood; H. W. Grimmitt, C.B.E.; P. McKearney, O.B.E.; *C. E. Mills; A. V. Milton; W. A. Smith; T. M. H. Stubbs; K. H. Tuson

## Code Drafting Committee on Private Generating Plant (ELCP/3)

*Chairman: appointment pending*
*Institution nominees:* J. P. Inglis; F. J. Mann; A. V. Milton

## Code Drafting Committee on Protection of Structures against Lightning (ELCP/4)

*Chairman:* H. M. Lacey, B.SC.(ENG.)
*Institution nominees:* P. McKearney, O.B.E.; †C. E. Mills; J. F. Shipley

## Code Drafting Committee on Supply, Metering and Consumers' Controls (ELCP/5)

*Chairman: appointment pending*
*Institution nominees:* C. W. Hughes, B.SC.; H. C. Spence; T. M. H. Stubbs; W. H. Walton; A. H. Young

## Code Drafting Committee on Telecommunication (ELCP/6)

*Chairman:* E. W. Anderson, B.SC.(ENG.)
*Institution nominees:* W. H. Brooks; C. King

‡ Deputy, C. E. Bedford, B.SC.(ENG.)
* Deputy, T. H. Adie
† Deputy, W. R. Whittington

**Joint MECP/ELCP Panel on Fire Alarms**
*Chairman:* W. H. Tuckey, O.B.E.
*Institution nominees:* C. King; F. H. Mann

**Code Drafting Committee on Heating, Refrigeration and Domestic Appliances (ELCP/7)**
*Chairman:* A. H. Young
*Institution nominee:* J. I. Bernard, B.SC.TECH.

**Code Drafting Committee on Lighting (ELCP/8)**
*Chairman:* W. J. Jones, M.SC.(ENG.)
*Institution nominees:* Mrs. M. B. Jackson; E. J. Sutton; A. H. Young

**Code Drafting Committee on Machines, Transformers, Rectifiers and Capacitors (ELCP/9)**
*Chairman:* F. H. Mann
*Institution nominees:* S. H. Harding; H. F. Jones, B.SC.(ENG.)

**Code Drafting Committee on Wiring Systems (ELCP/10) —now combined with ELCP/8**

**Code Drafting Committee on Use of Electronic Valves (ELCP/11)**
*Chairman: appointment pending*
*Institution nominees:*
K. A. F. Frost, B.SC.(ENG.)
The Chairman of the Electronics and Communications Section (*ex officio*

**Drafting Sub-Committee (ELCP/11/1)**
*Chairman: appointment pending*

**Code Drafting Committee on Maintenance of Electrical Switchgear (ELCP/12)**
*Chairman:* A. J. Gibbons, B.SC.TECH.
*Institution nominees:*
L. Drucquer (nominated by the Supply Section)
H. C. Fox (nominated by the Utilization Section)

**Drafting Sub-Committee (ELCP/12/1)**
*Chairman:* H. Astbury

**Code Drafting Committee on Street Lighting (ELCP/13)**
*Chairman:* J. M. Waldram, B.SC.(ENG.)
*Institution nominees:*
W. R. Stevens, B.SC.; B. L. Metcalf, B.SC.(ENG.)
The Chairman of the Utilization Section (*ex officio*)

**Drafting Sub-Committee (ELCP/13/1)**
*Chairman:* J. M. Waldram, B.SC.(ENG.)

**Code Drafting Committee on Abatement of Radio Interference Caused by Ignition Systems (ELCP/14)**
*Chairman:* W. Nethercot, M.A., B.SC.
*Institution nominees:* W. J. Bray, M.SC.(ENG.); The Hon. R. T. B. Wynn, C.B.E., M.A.

**Code Drafting Committee on Abatement of Radio Interference Caused by Discharge Lighting (ELCP/15)**
*Chairman:* Capt. C. Higgins, O.B.E., B.SC.(ENG.)
*Institution nominees:* E. M. Lee, B.SC.; W. J. Bray, M.SC.(ENG.)

**Code Drafting Committee on the General Aspects of Radio-Interference Abatement (ELCP/16)**
*Chairman:* E. M. Lee, B.SC.

**Code Drafting Committee on Earthing (ELCP/17)**
*Chairman:* H. W. Grimmitt, C.B.E.
*Institution nominees:*
P. B. Frost, B.SC.(ENG.); R. A. Marryat, B.SC.(ENG.); J. F. Shipley; G. F. Shotter; H. W. Swann, O.B.E.
The Chairman of the Utilization Section (*ex officio*)
The Chairman of the Supply Section (*ex officio*)
The Chairman of the Ship Electrical Equipment Committee (*ex officio*)

**Code Drafting Committee on Maintained Lighting in Cinemas (ELCP/18)**
*Chairman:* A. F. Steel, B.SC.(ENG.)
*Institution nominee:*
The Chairman of the Utilization Section (*ex officio*)

**Drafting Sub-Committee (ELCP/18/1)**
*Chairman:* A. F. Steel, B.SC.(ENG.)

**Code Drafting Committee on Flameproof and Intrinsically Safe Electrical Equipment (ELCP/19)**
*Chairman:* F. H. Mann
*Institution nominee:* R. A. Marryat, B.SC.(ENG.)

**Drafting Sub-Committee (ELCP/191)**
*Chairman:* F. H. Mann

**Code Drafting Committee on Overhead Electric Power Lines (ELCP/20)**
*Chairman:* H. W. Grimmitt, C.B.E.
*Institution nominees:*
C. O. Boyse, B.SC.(ENG.); P. K. Davis; P. B. Frost, B.SC.(ENG.)
C. H. E. Ridpath, B.SC.(ENG.); P. J. Ryle, B.SC.(ENG.)
The Chairman of the Supply Section (*ex officio*)

**Drafting Sub-Committee No. 1: Conductors (ELCP/20/1)**
*Chairman: appointment pending*

**Drafting Sub-Committee No. 2: Insulators (ELCP/20/2)**
*Chairman:* P. K. Davis

**Drafting Sub-Committee No. 3: Supports (ELCP/20/3)**
*Chairman:* P. J. Ryle, B.SC.(ENG.)

**Drafting Sub-Committee No. 4: Co-Ordination (ELCP/20/4)**
*Chairman:* H. W. Grimmitt, C.B.E.

**Code Drafting Committee on Abatement of Radio Interference Caused by Electro-Medical and Industrial Radio-Frequency Equipment (ELCP/21)**
*Chairman:* J. S. Forrest, D.SC., M.A.
*Institution nominees:*
H. W. Grimmitt, C.B.E.; E. M. Lee, B.SC.; T. M. H. Stubbs

**Drafting Sub-Committee (ELCP/21/1)**
*Chairman:* C. W. Sowton, B.SC.

**Code Drafting Committee on Maintenance of Insulating Oils (ELCP/22)**
*Institution nominee:* A. W. Stannett, B.SC.(ENG.)

**Code Drafting Committee on Climate Proofing of Electrical Equipment (ELCP/23)**
*Chairman:* B. Donkin, B.A.

**Code Drafting Committee on Maintenance of Control Gear (ELCP/24)**
*Chairman:* S. J. Emerson, M.ENG.
*Institution nominee:* R. A. Marryat, B.SC.(ENG.) (nominated by the Utilization Section)

**Code Drafting Committee on Measurement and Abatement of Radio Interference in Aircraft (ELCP/25)**
*Chairman:* N. G. Anslow

**Code Drafting Committee on Loading of Transformers (ELCP/26)**
*Chairman:* H. G. Bell, M.SC.TECH.
*Institution nominees:*
H. G. Bell, M.SC.TECH. (nominated by the Supply Section)
W. S. Lovely, B.SC. (nominated by the Utilization Section)

**Code Drafting Committee on Dust-Tight Electrical Equipment (ELCP/27)**
*Chairman:* F. H. Mann; *Institution nominee:* J. W. Binns

**Codes of Practice Committee for Mechanical Engineering (MECP/-)**
*Institution nominee:* F. H. Mann (24.6.54)

**Code Drafting Committee on Guarding of Machinery (MECP/4)**
*Institution nominee:* F. H. Mann (1.3.56)

**Code Drafting Committee on Oil-Firing Installations and Conversions (MECP/6)**
*Institution nominee:* H. E. Baker (7.2.57)

**Codes of Practice Committee for Buildings (BLCP/–)**
*Institution nominee:* Forbes Jackson (29.4.54)

**Code Drafting Committee on Daylight, Sunlight, and Artificial Light (BLCP/9)**
*Institution nominee:* W. R. Stevens, B.SC. (31.3.55)

**Code Drafting Committee on Lifts, Hoists and Escalators**
*Institution nominees:*
L. S. Atkinson (15.4.46); H. W. Fulcher (2.12.43)

**Code Drafting Committee on Mechanical Refrigeration**
*Institution nominee:* K. J. R. Cocke, B.SC.(ENG.) (4.3.48)

**Code Drafting Committee on Optical Projection Equipment for Schools**
*Institution nominee:* V. M. Roberts, B.SC. (8.8.48)

**Code Drafting Committee for Independent Fires**
(formerly convened by the Royal Institute of British Architects)
*Institution nominee:* J. I. Bernard, B.SC.TECH. (16.1.47)